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BREGMATIC FONTANELLE BONES IN MAMMALS

BY ADOLPH H. SCHULTZ

In every fontanelle of the mammalian skull accessory bones, varying in size and number, may occasionally be met with. These are known under the collective term of *fontanelle bones*, but special names have been given to those in the different fontanelles. Of more common occurrence are small bones in the sutures, called Wormian bones, which are similar in origin to the fontanelle bones and in principle are the same. Wormian and fontanelle bones may be found in close association and it is sometimes impossible to determine which bones belong to the fontanelle and which to the suture.

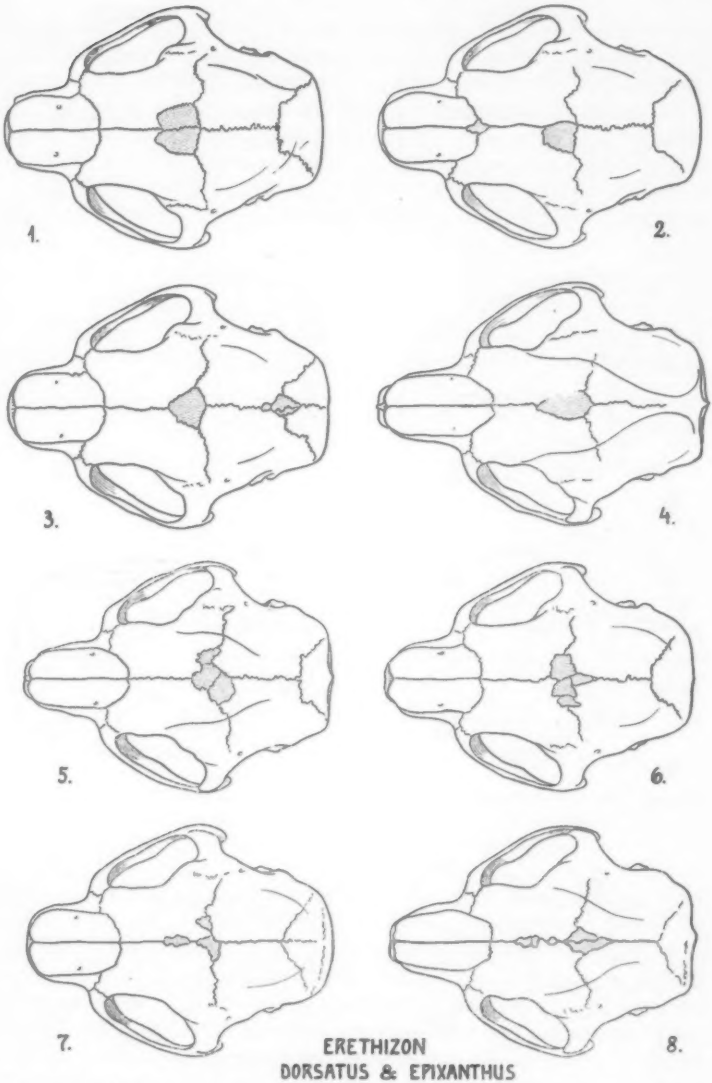
This paper is restricted to the consideration of the so-called bregmatic fontanelle bones, or shorter bregmatic bones, which are derived from accessory ossification centers in the great, anterior, or bregmatic fontanelle. These bones were first discovered in man in the sixteenth century by the physician Paracelsus, who gave them the name "ossiculum anti-epilepticum," believing them to be a remedy for epilepsy. Since that time various designations have been given to them by different authors: they have been termed "l'os de Bertin," "ossiculum verticis triangulare," "os interfrontale," "os fronto-parietale," "os fonticuli frontalis," "os interparietale anterius," "os bregmaticum," and many other names.

Special interest attaches to these bregmatic bones for the reason that in a few mammals they seem to be very common, while, on the other hand, in a large majority of mammalian skulls their occurrence is exceedingly rare and in many others they have never been found at all.

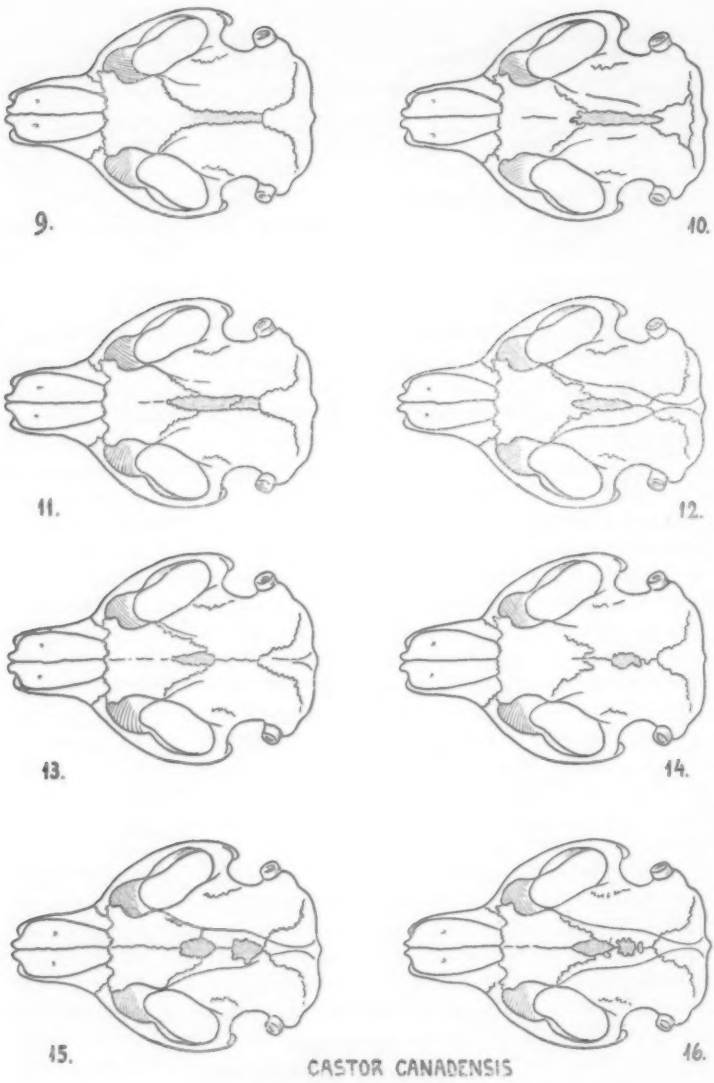
The observations and data used in this paper came from various sources. The author wishes here to express his thanks to Mr. G.

S. Miller and to Mr. H. Lang for their kind permission to examine some material in the National Museum in Washington and the American Museum in New York. In addition the writer has gone over his own collection of several hundred mammalian skulls and has also gathered from the literature a very considerable number of papers dealing with bregmatic bones.

The sketches of skulls with bregmatic bones given herein are intended to illustrate the variations in number, size, and shape of these bones in different mammals. Bregmatic bones occurred in over half of the porcupine skulls examined. In this animal their most frequent condition is double (fig. 1), perfectly symmetrical, and apparently lying entirely within the area of the frontal bones. In rarer instances there may be only one bregmatic bone (figs. 2, 3, and 4) and this may be unilateral (fig. 2), or central (fig. 3). Figure 4 shows a bregmatic bone that is partly obliterated or fused with a frontal bone. Several such cases were found in which the fontanelle bones were in a state of partial disappearance, and this at a time when the sagittal and coronal sutures were still open. This is of importance, since it shows the possibility that the observed frequency of bregmatic bones is less than the actual one, because in some cases these bones may have fused with the adjoining parts of the skull prior to the death of the animal. In human skulls incompletely obliterated bregmatic bones have been described by Gruber, LeDouble, Augier, and others, who found that the sutures of the bregmatic bone may be still open on the outer surface of the skull, while they have entirely disappeared on the inner surface, or vice versa. It is in the latter case that the anomaly would in most instances be overlooked. The bregmatic bones may be very irregular in shape; there may be three of them, as in figure 5, or even four, as in figure 6; they may lie close together (figs. 5 and 6) or be separated, and may be drawn out over both the sagittal and coronal sutures (figs. 7 and 8). There is no doubt that all the accessory bones in figures 7 and 8 may be properly designated fontanelle bones, since in fetal development, when accessory bones originate, the fontanelle sends out arms between the frontals and between the frontals and parietals. In the Canadian beaver the bregmatic bones are with few exceptions elongate in shape. They very frequently reach all the way back to the interparietal (figs. 9, 10, and 11). It seems most likely, from figure 9, that the anterior end of the fontanelle bone has become obliterated in this specimen. The bone may consist of only one piece or of two pieces (fig. 11), in which case the pieces lie one



FIGS. 1 AND 4. E. DORSATUS; FIGS. 2 AND 3. E. EPIXANTHUS. (COLL. SCHULTZ)
FIG. 5. E. DORSATUS (AMER. MUS.); FIGS. 6–8. E. EPIXANTHUS (NAT. MUS.)



FIGS. 9–16. C. CANADENSIS (AMER. MUS.)

behind the other. This is in contrast to the condition found in porcupines, where the pieces lie usually side by side. The bregmatic bone may be short but still lie for the most part between the parietals (fig. 12); again it may project far between the frontal bones, as in figure 13, or appear as a true Wormian bone in the sagittal suture (fig. 14). Finally, two or more fontanelle bones may be distributed over the entire region of the great fontanelle (figs. 15 and 16). In the European hedgehog (fig. 17) bregmatic bones are very common. They vary in number

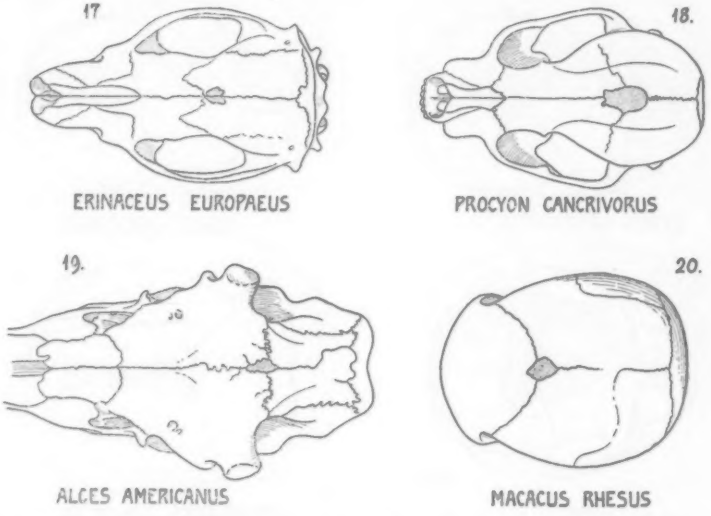
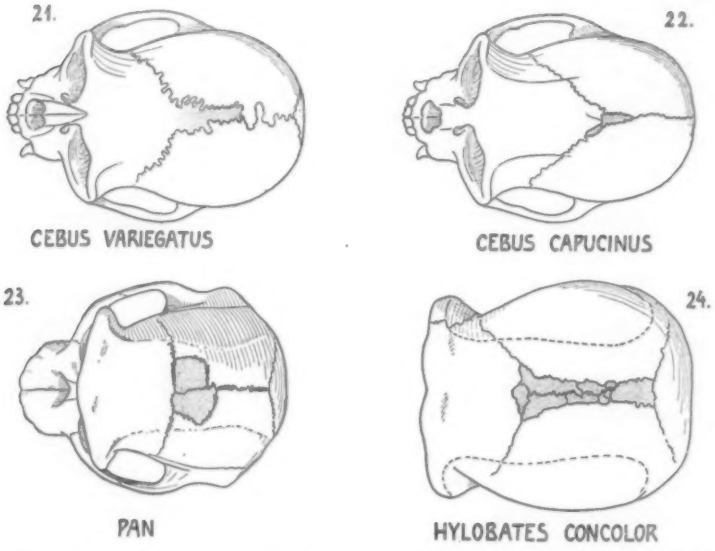


FIG. 17. E. EUROPÆUS (COLL. SCHULTZ); FIG. 18. P. CANCRIVORUS (AFTER ELLIOT, 1904); FIG. 19. A. AMERICANUS (COLL. SCHULTZ); FIG. 20. M. RHESUS (AFTER HRDLIČKA, 1903)

from one to three but are for the most part very small. In the crab-eating raccoon, another mammal in which this anomaly frequently occurs (v. Jhering), the bregmatic bone seems to be always single, centrally situated, and of considerable size. Figure 18 gives a typical instance of this. In the moose skull shown in figure 19 the bregmatic bone is small and there are short irregular sutures in the corners of the nearby frontal bones. In another moose, and also in a cow skull, the writer observed a fairly large accessory bone near the anterior (nasal) end

of the interfrontal suture.[1] In catarrhine monkeys various forms of bregmatic bones have been described; the one shown in the macaque (fig. 20) is perhaps the most typical and in this case is associated with divided parietal bones. In platyrrhines the fontanelle bones are a not very rare finding. They usually lie in the direction of the sutures at the sharp median angle of the frontal bones, as shown in figure 22. It can not be determined with certainty whether figure 21 represents an anteriorly obliterated bregmatic bone or an unusually long proc-



FIGS. 21 AND 22. CEBUS (COLL. SCHULTZ); FIG. 23. PAN (AFTER SELENKA, 1899); FIG. 24. HYLOBATES (AFTER RANKE, 1899)

ess of the frontal bone extending between the parietals. The double quadrangular bregmatic bone in the chimpanzee (fig. 23) lies entirely in the region of the parietals. This case shows clearly that the shape of the bregmatic bones does not always repeat the shape of the fontanelle. The eight accessory bones along the entire course of the sagittal suture in the gibbon skull (fig. 24) resemble very much the condition shown before

[1] These bones probably originated in the so-called metopic fontanelle which itself is derived from the frontal arm of the great fontanelle (Schultz, 1918).

in the beaver. It is difficult to decide which of these bones belong to the anterior fontanelle, which to the posterior fontanelle, and which, in the middle, may be suture or Wormian bones. This skull furnishes a classic example to demonstrate that the fontanelle and suture bones are in principle one and the same thing. Hardly less than 150 cases of bregmatic bones in man have been reported. Figure 27 shows the type which is probably the most common. The bregmatic bone given

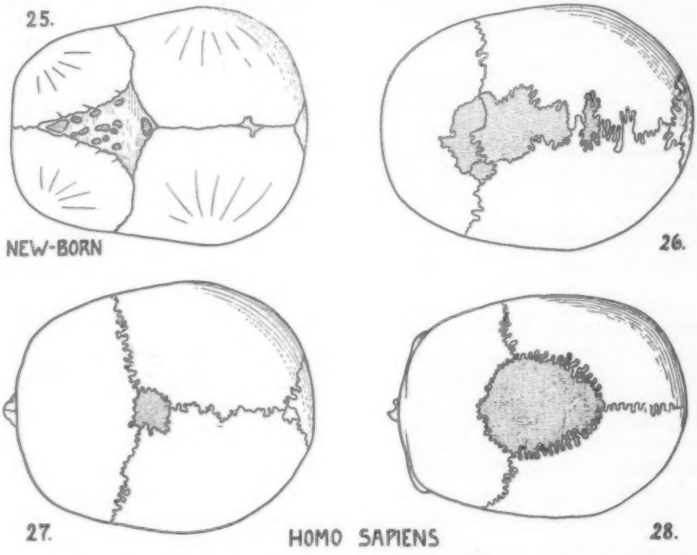


FIG. 25. HOMO (AFTER BARCLAY-SMITH, 1910); FIG. 26. HOMO (AFTER BARCLAY-SMITH, 1909); FIG. 27. HOMO (AFTER HOLL, 1884); FIG. 28. HOMO (AFTER MACDONELL, 1907)

in figure 28 is most likely the largest on record. Figure 26 shows a case with four such bones, and figure 25 one with thirteen.

The table in this paper represents a compilation of all the cases of bregmatic bones in mammals, found in the literature, together with the author's own observations. The first column of figures gives the total number of skulls of each species or group of mammals examined. Only those skulls are included, of course, in which the chief sutures on top had not yet become obliterated. Unfortunately, many of the authors

MAMMALS	AUTHOR	TOTAL NUMBER EXAMINED	CASES WITH BREGMATIC BONES	
			Absolute	Relative
Marsupialia	Gruber, Leuckart	—	3	—
Insectivora				
Erinaceus auritus	D'Alton, Otto	—	2	—
Erinaceus europaeus	Bojanus	—	Several	—
Erinaceus europaeus	Le Double	20	16	68.0%
Erinaceus europaeus	Schultz	5	1	
Galeopithecidæ	Cuvier, Wiedemann	—	Several	—
Edentata				
Manidæ	Leuckart	—	1	—
Bradypodidæ	v. Jhering	15	2	13.3%
Bradypodidæ	Carus, Cuvier, Köstlin	—	3	—
Myrmecophagidæ	v. Jhering	22	0	0
Myrmecophagidæ	Otto, Wiedemann	—	1	—
Dasypodidæ	v. Jhering	35	0	0
Rodentia				
Lepus variabilis	Gruber	—	1	—
Lepus cuniculus	Howes	hundreds	3	—
Lepus cuniculus	Schultz	10	1	10.0%
Sciurus vulgaris	Leuckart	—	1	—
Pteromys volans	Gruber	—	1	—
Castor canadensis	Schultz	22	12	54.6%
Pedetes cafer	Gruber	—	1	—
Hypudæus	Leuckart	—	1	—
Hystrix	Ficalbi	—	1	—
Erethizon	Schultz	53	27	51.0%
Carnivora				
Pinnipedia	Gruber	—	1	—
Felidæ	v. Jhering	49	1	0.9%
Felidæ	Schultz	62	0	
Felidæ	Leuckart	—	1	—
Canidæ	Ficalbi, Gruber, Leuckart	—	3	—
Canidæ	v. Jhering	85	2	1.4%
Canidæ	Schultz	56	0	
Ursidæ	Gruber	—	2	—
Procyon cancrivorus	Elliot	—	1	—
Procyon cancrivorus	v. Jhering	11	5	45.4%
Nasua	v. Jhering	21	0	0
Mustelidæ	v. Jhering	10	0	0
Mustelidæ	Schultz	21	0	0
Cetacea	Gruber	—	1	—
Ungulata				
Bovidae	Gruber	—	2	—

MAMMALS	AUTHOR	TOTAL NUMBER EXAMINED	CASES WITH BREGMATIC BONES	
			Absolute	Relative
Cervidæ	Schultz	—	1	—
Primates				
Hapalidæ	v. Jhering	41	2	4.9%
Cebidæ	Gruber, Hrdlicka, Leuckart, Otto		6	—
Cebidæ	v. Jhering	166	9	6.8%
Cebidæ	Meckel	28	4	
Cebidæ	Schultz	26	2	
Cercopithecidæ	Ficalbi, Hrdlicka, Leuckart, Otto		6	—
Cercopithecidæ	Schultz	72	0	0
Hylobatidæ	Leuckart, Ranke	—	3	—
Anthropomorphæ	Frassetto, Staurenghi, Selenka		3	—
Homo (White)	Gruber, Le Double	12,923	81	0.6%
Homo (Indian, Eskimo)	Russell	1,333	?	0.5%
Homo (Other races)	Bianchi	434	0	0
Homo (All races)	Augier	1,400	?	0.2%

did not state the number of skulls in the series in which they found bregmatic bones, so that in such instances the interesting question as to the frequency of the anomaly can not be determined. The second column gives the absolute number, and the third column the percentage frequency, wherever known, of skulls with bregmatic bones. This table illustrates, first of all, the wide distribution of these accessory bones among mammals. They have been found in at least 63 species belonging to 10 different orders. Of special interest is the relative frequency of the bregmatic bones in the different mammals. These bones are found in the European hedgehog in 63 per cent of the cases, and Bojanus even asserted that they were constant in this species. Second in frequency is the Canadian beaver, in which the bones were found in 54.6 per cent of the skulls. The beaver is followed closely by another rodent, the porcupine (both the Canadian and yellow-haired species), with a frequency of 51 per cent. Apparently only a single species of carnivorous animal possesses this anomaly to any marked extent; this is the crab-eating raccoon, which shows a frequency of 45.4 per cent.[2] This surprisingly common occurrence is of special

[2] Since this paper went into press the author obtained the skulls of a *Procyon cancrivorus* and of a *Nasua narica* neither of which show bregmatic bones.

interest in view of the fact that the author never found the accessory bone in the close relative of this raccoon, the *Procyon lotor*, nor has it been observed in *Nasua* or in any of the Mustelidæ. According to Ficalbi and to Schwalbe, bregmatic bones are almost the rule in platyrrhine monkeys; however, the writer found a frequency of only 6.8 per cent in this group of primates. By far the most extensive statistics available are for man. Here, out of series totaling over 16,000 skulls, a bregmatic bone never occurred in more than 0.6 per cent.

From this table it may be concluded that bregmatic bones are represented in almost all groups of mammals and that while they are, as a general rule, very rare, yet in scattered instances they may become quite common, indeed almost typical, for isolated species. Examples of this have been found in one insectivore, three rodents, and one carnivore.

It has been stated that the occurrence of bregmatic bones is always restricted to the male sex. This seems to be nearly correct in the case of man. Gruber, for instance, found the anomaly in 38 male and only 3 female skulls, and a large majority of the human cases scattered through the literature are of males. However, in other mammals this correlation with sex does not hold true. In the beaver the author found the bones in about equal numbers of male and female skulls, and in the porcupine they were present twice as frequently in females as in males.

The numerous interpretations and hypotheses as to the significance of bregmatic bones seem to depend a good deal on the number and variety of cases that have come to the attention of the respective authors. Curvier believes the bregmatic bone to be single and to be an os interparietale anterius. Coraini considers it double and distinguishes a pars frontalis and a pars parietalis. Maggi claims that bregmatic bones in mammals, including man, originate from four ossification centers, which he believes to correspond to four dermal bones in the bregmatic region of the Ganoides, Stegocephales, and some fossil reptiles. Prior to Maggi, this hypothesis seems to have been in part expressed by Gulliver, who states that bregmatic bones may be regarded as reversion towards ancestral types, such as ganoid fishes.

Based upon the cases which the author has collected, it may be concluded that a single bregmatic bone is by far the most frequent form of the condition in man and most other mammals. However, three, four, five, even as many as thirteen bregmatic bones have been

described in some skulls, which proves that there is no firm rule regarding the number of accessory bones in the great fontanelle.

It has been asserted by some Italian scientists that bregmatic bones occur especially in criminals and lunatics. This does not seem very probable, to say the least, in view of the fact that the same anomaly is so generally distributed among mammals. In human hydrocephalic skulls fontanelle bones are rather common and a considerable series of such cases has been actually described. In two hydrocephalic skulls of newborn infants, which the author had an opportunity to examine, several small ossicles were found in the frontal arm of the greatly enlarged bregmatic fontanelle. This is of importance, since it shows that these bones are more apt to exist in unusually large fontanelles than in those of normal size.

Fontanelle bones, according to LeDouble, may appear in man as early as at four and a half months of fetal development, and most frequently, according to Ranke, during the sixth month or slightly later. As a rule, they are first very small ossicles, which may soon afterwards fuse to form larger bones. It is often impossible to tell, therefore, how many ossification centers have given rise to one large bregma bone in an adult skull. The size and shape of the bregmatic bones are determined by their own rate of growth in competition with that of the adjoining bones. The more rapidly the fontanelle bones grow, the larger the area of the frontals or parietals they will eventually replace.

Since the number of bregmatic bones varies considerably and these, furthermore, may have originated in part through fusion of many more ossification centers, and since these bones may be situated anywhere in the region of the great fontanelle or the sutures nearby, it is never justifiable to ascribe any phylogenetic or atavistic significance to them, such as Maggi and others have done. No one would ever attempt such an explanation of the ordinary small Wormian bones found in so many sutures, and yet the latter are in principle the same as the fontanelle bones.

Coraini and others believe that there is nearly always a direct connection between the occurrence of bregmatic bones and the condition of wedge-shaped frontale projecting far back between the parietals, which is the rule in many different mammals—for instance in most *Cebus* monkeys. However, just as many bregma bones can be seen in skulls with the coronal sutures running in an almost straight line from side to side as in skulls in which these sutures enclose a sharp angle between them.

When present, the bregmatic bones in very young animals certainly do tend to close over the fontanelle, and this sooner, probably, than if the closure were left to the frontal and parietal bones alone. The frequency of these accessory bones in hydrocephalic skulls, in which the great fontanelle is wide open, speaks in favor of the opinion that fontanelle bones may play the rôle of protecting the brain in places where it would otherwise be covered for a long time only by membrane. It seems probable that these bones may be regarded as a new acquisition in mammals, in which, here and there, the normal skull bones may prove insufficient to close the fontanelle in due time. This theory may be either supported or overthrown when our knowledge of the size and normal time of closure of the great fontanelle in mammals has been lifted above its present rudimentary state. Only when we know more about these conditions will it be possible to tell whether the fontanelle remains patent unusually long in the otherwise normal skulls of those few scattered species in which bregmatic bones appear with very high frequency, and whether the presence of such bones tends to overcome this retarded ossification.

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Dept. of Embryology, Carnegie Institution of Washington, Baltimore.

THE COMBING CLAWS OF THE BEAVER

By Vernon Bailey

[*Plate 9*]

Few mammals show more perfect adaptation throughout to habits and mode of life than the beaver, but to be fully appreciated these adaptations must be seen in actual operation. The broad paddle-like tail has so many vitally important uses that one can scarcely understand how the muskrat with his radically different tail can get along in a life equally aquatic. The habits of the muskrat, however, are just as different from those of the beaver as are the features of his anatomy. He does not, tug-like, propel logs through the water so as to require a powerful side-rudder, nor carry heavy loads in his arms and walk erect so as to require a strong rear balancing prop, nor cut down trees where force is required from the rear to press his chisel-like incisors deep into the wood, nor do any of the many things which have developed the unique tail worn by the beaver.

The beaver's tail is only one of the many wonderful adaptations to his mode of life. Teeth, mouth, ears, eyes, fur, feet, and hands are equally well adapted to his needs. The hind feet are large, powerful, and fully webbed to the tips of all five toes, as they are the main organs

for swimming, as well as for carrying the weight of the body on land. The soles of the feet are long and broad and for the size of the animal give a ground surface comparable to that of the human foot, enabling the beaver to walk firmly in an upright position. The toes of the hind feet are long and strong for carrying the broad webs, and the three outer toes are straight and armed with thick, dull nails that have no apparent function beyond protecting the ends of the toes. The two inner toes, however, curve toward the body and the nails are highly specialized and have been called *combing claws* and *louse-catching claws*. The inner toenail is the less specialized but consists of a long double-edged nail that clamps down over a long soft lobe, opening and closing like a duck's bill. The second toenail has caused much speculation and is often called the *double-nail* or *split-nail* of the beaver. Between the lobe of the toe and the real nail is a horny growth with a sharp, finely serrate upper edge over which the real nail fits down with its two sharp lower edges when pressed down and opens up slightly when the pressure is removed. This could be called the fine toothed comb while the inner toenail is more of a coarse comb in effect.

Never until I had tame beavers to study did I fully understand the use and structure of these peculiar nails nor the reason for the incurving form of the two inner toes. My young beavers would sit and comb their fur for a half hour at a time, making elaborate toilets when they had nothing else to do. The curved finger nails of the hands were used on certain parts of the body, around the breast and head, the base of the tail, and especially in the short hair around the anus where the oil from the two oil glands is caught and held for distribution. These finger nails were simply raked through the fur in a coarse combing and oil-distributing process, preliminary to the final, thorough combing with the hind feet. Then with one foot at a time the sides, shoulders, and belly were sytematically gone over with inward, rotary strokes of the two double claws of the hind toes, until every kink and snarl of the fur was straightened out and not improbably, as Seton suggests, any mites or insect parasites combed out and off.

At any rate beavers are singularly free from parasites, two small brown beetles (*Leptinillus validus*) being the only ones discovered on four old beavers taken for specimens in Wisconsin. No parasites of any kind were found on the six young beavers kept in captivity, although all did much combing. Unquestionably the early and constant use of these claws for thousands of generations has perfected their present form and adaptation, which might even suggest improved methods of caring for dressed furs.

RIGHT HIND FOOT OF ADULT BEAVER, SHOWING TWO INNER CLAWS MODIFIED FOR COMBING THE FUR
About natural size

The fur of live beavers is smooth and even and beautifully soft and fine in texture. In wearing apparel it eventually becomes tufted, wavy, matted, and coarse in appearance, simply for lack of proper care and combing. If a simple method of caring for the fur as efficiently as the beavers care for it could be recommended, fur garments would be more permanently beautiful and valuable. This, however, is a subject for furriers rather than for biologists to work out, and the best methods should be made public rather than kept as trade secrets.

Biological Survey, Washington, D. C.

OBSERVATIONS ON THE BURROWING HABITS OF MOLES (SCALOPUS AQUATICUS MACHRINOIDES)[1]

By Frederick L. Hisaw

The exact method by which the mole excavates its burrow has long been in question. Several authors have expressed opinions which were based for the most part on the anatomy of the animal, but apparently no one has made a detailed study of the mole during the process. During the last two years the writer has investigated the burrowing activities of the mole and has made many field and laboratory observations. Laboratory apparatus has also been devised to enable the observer to watch the movement of the mole while at work in its burrow.

CONTROVERSY ON BURROWING METHODS

Cuvier (1817) thought the mole loosened the soil with its nose, which was provided with a peculiar bone for the purpose. Later it was shown that this was not correct. Carpenter (1857) states that "the form of the anterior limbs, and the powerful muscles with which they are furnished, enables the animal, not merely to dig through the soil cutting through roots, etc., which may traverse it, but also to throw backwards with great energy the earth which has been removed at each stroke."

Herrick (1892) describes the burrowing method as a swimming motion. He says: "The mole may be almost said to swim through

[1] Contribution no. 64 from Department of Zoology, Kansas Agricultural Experiment Station. The writer wishes to thank Mr. Fred Emery for his help with the apparatus.

the earth, its feet not being beneath the body, but on either side, and so armed with broad spade-like claws, and so highly provided with muscles as to glide rapidly through the soft earth. During the passage through the earth, the back and shoulders wedge the earth upward, so that the course of the animal can be followed by the observer above."

Wood (1910) states that the mole digs its burrow by pushing the dirt aside rather than by bringing it to the surface. In describing the process he says: "The fore paws are thrust forward in front of the nostrils, and by a sort of swimming motion the earth is pushed aside, the head at the same time being advanced and raised."

METHODS AND APPARATUS

The general method followed in this work was to make extensive field studies of the types of burrows excavated under natural conditions, and to construct laboratory apparatus to determine the way in which each kind of burrow was formed. Moles do not expose themselves at the surface while digging, so it was possible to get only general ideas concerning the movements of the animal from field study. The field work served only as a guide for laboratory experimentation while all the actual observations of the activities of the animal itself were made through the use of apparatus devised especially for the purpose. The moles used in the experiments had usually been kept in captivity for some time. They were tame and accustomed to being handled. They did not seem to be frightened when subjected to the apparatus, and would usually eat, if offered food, while going through the experiments.

The apparatus used in the experiments consisted of boxes with glass sides and bottoms. This made it possible to observe the activities of the mole both from the side and from below. The cages used for watching the mole from the side were 3 inches wide, 2 feet long and 18 inches deep. A narrow box of this kind provided ample room and at the same time kept the animal close to the glass. The boxes used for studying the activities as seen from below were of different dimensions depending upon the size of the glass used for the bottom. These boxes were supported high enough above the floor to enable a person to sit under them, the movements of the mole being followed by the aid of an electric light.

ADAPTATIONS FOR BURROWING

The mole is adapted to its fossorial life by having the bones and muscles of the pectoral girdle greatly modified. By the lengthening of the presternum, the pectoral girdle is moved forward opposite to the base of the skull. The posterior end of the scapula is in about the same position as that found in all mammals, but is greatly elongated to accommodate the forward movement of the girdle. The bones of the fore limbs are large, short and flat, and are adapted for both strength and the attachment of muscles. The neck is sufficiently shortened to give the fore legs the appearance of articulating with the body alongside of the head. The possession of a short neck and a forwardly placed pectoral girdle enables the mole to bring its fore feet together in front of its nose for excavating earth from the end of the tunnel.

The feet of a mole are also remarkably adapted to its burrowing habits. The claws of the fore feet are broad and spade-like, and in digging are pushed against the earth like so many shovels. The motion of the feet in digging is slow when compared with that of other fossorial animals that loosen the soil by means of pointed pick-like claws, which are usually operated very rapidly. The claws of a mole are operated by a scooping motion, as a man would push a shovel, and their effectiveness is due not to the momentum which is gained before the claws strike, but to the great muscular force with which they are pushed. Also the breadth of the fore feet not only accommodates the great claws, but is useful in transferring loose earth. The paws are also furnished with a fringe of stiff hairs on the palmar margins; some of them being tactile, according to Kazzander (1909). In addition to their tactile function, it is probable that these hairs also aid in keeping the earth in front of the paw while digging. The hind feet are webbed to the last joint of the toes, which are provided with sharp claws. The web between the toes aids the foot in the process of kicking the loose earth from beneath the belly, while the claws help hold the body against the end of the burrow during the operations of the fore feet.

EXCAVATION OF BURROWS

The digging is done entirely with the fore feet, which are so associated with the greatly specialized bones and muscles of the pectoral girdle as to enable the mole to exert an almost unbelievable lateral force. The two main movements of the fore legs used in digging are anteroposterior strokes and straight lateral thrusts. From an examination

of the anatomy of the pectoral girdle, Slonaker (1920) concluded that a pivotal rotary motion of the fore leg would be very slight, if at all possible, and that the two main pedal movements were forward and backward, and up and down.

The way in which a mole uses the fore legs can be demonstrated by placing one on a table and holding it down with the palm of the hand. One is immediately impressed with the fact that a mole does not resist the pressure by raising its body or by a dorso-ventral motion of the front feet, but by rotating the fore part of the body and pushing the hand away with a vigorous thrust straight out from the body. A closer examination shows that the force is produced by a combined effort of both fore legs. Apparently, the animal can exert its greatest physical effort when the two fore feet are pushing against opposite points lateral to the pectoral region. The rotation of the body brings one fore foot against the observer's hand and the other against the table with the pectoral region of the animal directly between them and the push is executed by extending both legs laterally. Subsequent discussion will show that the mole also uses this action in excavating a burrow.

It seems evident that the observations upon which the idea that a mole "swims" through the soil are based, were obtained from watching captive animals make their way through very soft earth. If a mole is placed in a glass bottomed box which contains loose soil, and the digging process observed from below, it will be seen that progression is made by a swimming motion, but if the soil is packed until it is as solid as that ordinarily found in nature, the mole does not "swim," but digs.

Under natural conditions, the mole excavates two kinds of tunnels; surface runways or ridges, which are used for collecting food, and deep passages which are used as headquarters and for thoroughfares to feeding grounds. The surface runways are formed by pushing the earth up in ridges and do not involve the problem of transportation, while the deep passages are formed by digging the earth loose and carrying it either to the surface and depositing it in "hills" or putting it in discarded tunnels.

EXCAVATION OF SURFACE RUNWAYS

If a mole is observed making a surface runway or ridge in the field, it will be seen that it is not a steady progression as would be expected if the animal were gliding forward by a swimming motion, nor does it present the appearance of an object being driven through the soil, as

would be true if the earth were being pushed up by the animal's back. The earth is thrown up on the right and then on the left and in front, there being no rhythm in the process but there is every appearance of industrious work. The process of ridge formation can be studied in the laboratory by watching the animals dig in cages having glass bottoms, which enable the observer to watch the movements from below.

Excavation as seen in the laboratory appears to be done entirely by lateral motions of the fore feet. When the earth is pushed up by the left foot the mole rotates the front part of the body about forty-five degrees to the right, brings both feet together at the lower right side of the burrow, and, after a few rapid thrusting motions to place the

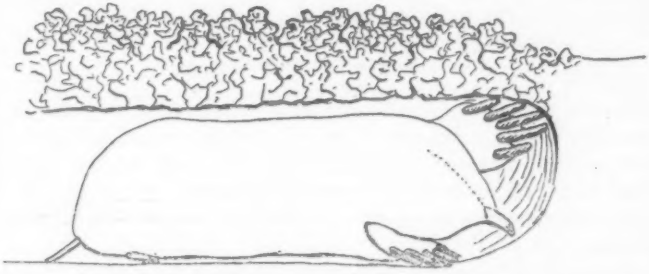

FIG. 1. RIDGE CONSTRUCTION

The body is rotated about forty-five degrees to right or left and the earth is pushed up by extending the front legs laterally. Drawn by S. Fred Prince.

claws, the left leg is vigorously extended upward. If the right foot is used in throwing up the soil, the reverse of this is true. In both cases, the leg that is used to push the earth upwards is aided by the extension of the other, which is held against the bottom of the burrow. During the entire process the nose is held between the feet and employed in making rapid and detailed examinations. It is in no way used for loosening the soil but seems to function entirely as a tactile organ for directing the powerful claws.

Observations in the field show that during drouths the old surface runs are often deepened. This is done by driving a new tunnel beneath the old, the action of the feet in this instance being the same as that described for the formation of ridges. As the new run is excavated, the earth is pushed up into the old discarded burrow above. This

seems to be a clever way of saving labor. The remodeling is obviously for the purpose of feeding on earthworms and insect larvæ, which require moist earth and if the animal should construct an entirely new system deep enough to reach its food supply, not only would it have to break the hard dry surface, but remove much more earth in order to reach the proper depth. The deepening process may be repeated several times during a season, and as a result, the ridges are often seven or eight inches in width and six inches high, while the tunnel may be five or six inches below the surface.

Moles do not always go about their work aimlessly, but at times seem to show some discretion. They may cease their digging and back up to make a thorough examination of the walls of the tunnel. Occasionally, a decision seems to be reached, and on resumption of work the burrow is, perhaps, driven in a different direction.

CONSTRUCTION OF DEEP TUNNELS

The deep tunnels of a mole's system of runs may be from six inches to two feet below the surface of the soil. At this depth, the earth can not be pushed upward, nor to the side, but must be loosened and carried away. This excavated earth may either be brought to the surface and deposited in mounds, or packed in some discarded part of the system.

Laboratory observations show that the earth is loosened with the claws of the fore feet, and that only one paw at a time is actively engaged in digging. When the left foot is digging, the right is held either against the right, or upper right side of the burrow, and the soil is loosened by lateral strokes. When the right paw is used, the reverse is true. If the inactive foot is held against the side of the tunnel, the digging strokes are almost horizontal and backward, but if held against the upper right or left sides, the strokes are directed downward and backward. At each stroke the excavated earth is thrown beneath the belly. Periodically one of the hind feet reaches forward under the body and kicks the loose earth to the rear of the animal.

After a quantity of earth is loosened and piled in the tunnel behind the mole, the animal turns about and pushes the dirt out of the burrow with one of the broad front paws (Fig. 2). To do this, the head and shoulders are turned abruptly to the side in a horizontal position, which permits one of the fore feet to come in contact with the pile of earth, which is driven forward by straight lateral thrusts of the paw. As the mole maintains this position and progresses along the burrow,

the earth is successively shoved forward at each step. At times the mole may back up to collect earth that has slipped past its paw, or to change over and use the other fore foot.

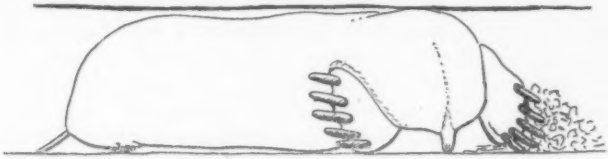

FIG. 2. TRANSFERRING EARTH IN A DEEP BURROW

The head and shoulders are turned abruptly to the right or left and the loose earth is pushed forward by one of the fore paws. Drawn by S. Fred Prince.

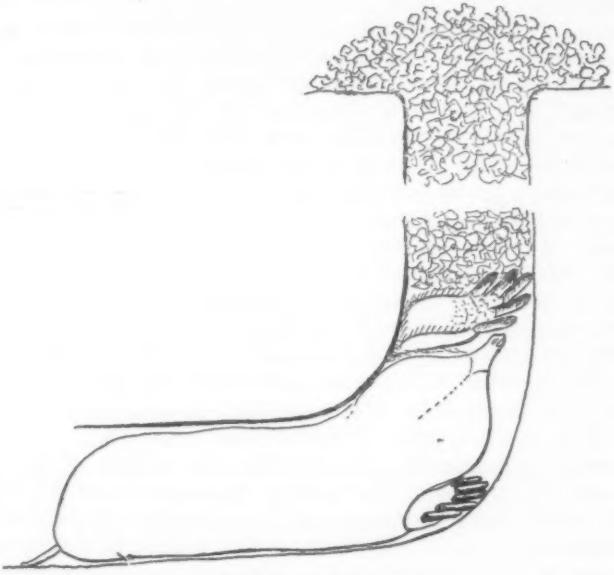

FIG. 3. MOUND CONSTRUCTION

The body is turned at an angle and the earth is pushed to the surface by extending the fore legs laterally. Drawn by S. Fred Prince.

On reaching the point where the earth is discharged from the burrow, if it is being deposited at a mound, the mole turns the fore part of its

body at an angle, and pushes the earth to the surface by the same movements as those described for ridge formation. The passage through which the excavated earth is forced from the tunnel to the exterior is always closed by a column of loose soil, and as each load is added at the lower end of the passage, an equal amount is pushed out at the top. This method of disposing of the excavated earth accounts for the characteristic appearance of a mole hill. An examination of such a hill will reveal that it is constructed by forcing the earth up in the center and letting it fall on all sides. It is also very evident that the mole does not expose itself at the surface while building the mound. The excavated earth is not always brought to the surface, but may be deposited in some discarded part of the burrow. When this is done, the soil is tightly packed into a part of the system which is to be abandoned.

The method described above for the digging of deep tunnels and the transferring of earth can be demonstrated in the laboratory. The apparatus needed for this is a very narrow, deep box, 3 inches wide by 2 feet long, at least a foot deep, and with one or both sides of glass. Earth should then placed in the box and packed very tightly. An arrangement of this kind not only simulates all of the conditions under which a mole works in a deep tunnel where the earth cannot be shoved aside, but enables the observer to watch every move the animal makes. Moles are very favorable subjects for this kind of apparatus. Their vision is very limited so the movements of a person's body or hands do not disturb them, and the distance from which observations can be made is limited only by the thickness of the glass.

When a mole was released at one end of a box of this kind, it would first drive a tunnel two or three inches below the surface, using the movements described for ridge formation. On reaching the opposite end of the box from where it was introduced, the animal would turn downward and construct a second tunnel by pushing the earth up into the first, thus giving an excellent demonstration of the way in which surface burrows are deepened in time of drouth. If the mole was not disturbed, it would continue burrowing backwards and forwards, disposing of the excavated earth by shoving it into the tunnel above. If, however, one closed the upper tunnel into which the earth was being pushed by tamping the soil down from above, the activities of the animal were entirely changed. It could no longer make its burrow by pushing the soil aside and all the conditions under which a deep passage is excavated were established. Under these circumstances, the mole

would immediately begin digging the earth from the end of the burrow, and transfer it in the manner described above, and if the soil was not tamped at the end of the box opposite the direction in which the animal was burrowing a mound was usually constructed by bringing earth to that place and forcing it to the surface.

DAILY ACTIVITY

There has been considerable discussion as to whether a mole is nocturnal or diurnal in its habits. Scheffer (1912) made a rather elaborate study of the daily activity of the mole by pressing down the runways and noting the time they were repaired. He found that 135 repairs were made during the night and 116 during the day. Examinations were also made during all hours of the day and night, and it was found that the mole may be working at any time.

The captive moles also furnished an opportunity to study this point in the laboratory. It was noticed that moles while moving about in the cage would occasionally come to the surface of the soil and thrust their noses out. When the nose was withdrawn, it left a pit in the earth and, consequently, a record. By periodically smoothing the surface of the soil and counting new pits that were formed, a fair idea of the daily activity was obtained. During a period of 65 days three moles made 574 pits during the night, and 678 during the day. This is an average of 8.8 per night, and 10.3 per day. Observations were also made at hours during both day and night, and it was possible to find the moles working at any time. These observations coincide with those made by Scheffer in the field and agree with his conclusion that the mole is neither strictly nocturnal nor diurnal in its habits.

SUMMARY

1. The mole excavates its burrow by antero-posterior strokes and lateral thrusts of the front feet, the vertical angle of the movements being regulated by rotating the fore part of the body.

2. In the excavation of shallow burrows the earth is disposed of by being pushed upward to form a ridge, while in the construction of deep tunnels, from 6 inches to 2 feet below the surface, the earth is loosened with the strong claws of the fore feet and transferred either to the surface or to some vacated part of the burrow.

3. Loose earth is transferred and pushed to the surface by lateral thrusts of the fore feet.

4. Moles often deepen surface burrows during drouths by driving a new tunnel under an old one and the excavated earth is disposed of by being pushed up into the burrow that is being vacated.

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ON THE IDENTIFICATION OF SIMIA SYRICHTA LINNÆUS

By Angel Cabrera

Simia syrichta, based on Petiver's *Cercopithecus luzonicus minimus*, seems to have been one of the more difficult Linnæan species to determine with exactitude. It was placed by Schreber among the South American monkeys; Lesson treated it as an imperfectly stuffed or inaccurately drawn saimiri, whereas Shaw thought it identical with or very near to "*Lemur*" (= *Microcebus*) *murinus* of Gmelin; and, only eleven years ago, Oldfield Thomas pronounced it to be "nothing but the one monkey found in Luzon, viz., *Macaca philippensis*, *philippinensis*, or *palpebrosus* auctorum."[1] Many other authors, however, preferred to adhere to the opinion of Desmarest, which included *Simia syrichta* among the species considered "comme factices ou tout-à-fait indéterminables,"[2] and they either ignored or expressly rejected it. The late Doctor Elliot discussed this matter to some extent, and thought to settle it by saying: "Linnæus' *syrichta* is therefore considered as undeterminable."[3]

Now, it seems to me advisable to follow with this mysterious species the system advocated by Thomas for all the Linnæan species based on references, and not on actual specimens, a system consisting only in searching for the original bases of Linnæus' quotations. By doing so in the present case, we arrive at a somewhat unexpected result, but, in my opinion, to the only one which may be considered acceptable.

The Linnæan text about *Simia syrichta*, on page 29 of the tenth edition of Systema Naturæ, consists only of the following scanty lines:

> S. caudata imberbis, ore ciliisque vibrissatis. *Syst. Nat.* 3.
> Cercopithecus luzonicus minimus. *Pet. gaz.* 21. *t.* 13. *t.* 11.
> *Habitat in* Luzonum *insulis.*

The first reference sends us to page 3 of the sixth edition of Systema Naturæ, where Petiver's Gazophylacium, plate xiii, figure 11, is again referred to as the basis of the species. Unfortunately, Petiver's figure, reproduced some time afterwards by Schreber, is only, as Thomas very appropriately says, "a ghastly travesty" of any more or less monkey-like animal, with a young one tied under its belly by means of a grass belt. On seeing such a ludicrous drawing, the doubts of zoologists

[1] Proc. Zool. Soc. London, 1911, p. 129.
[2] A. G. Desmarest, Mamm., I, 1820, p. 80, footnote.
[3] D. G. Elliot, Review Primates, II, 1913, p. 250.

about the identity of the species seem only very natural. It is a well known fact, however, that Petiver's notes and figures of Philippine animals were based on the papers sent to England by the German Jesuit missionary G. J. Kamel, better known as Camelli, which are preserved, I think, in the British Museum library. These papers, therefore, must contain the true basis of *S. syrichta*. I have not seen them myself, but the part referring to the so-called *Cercopithecus*, as well as four drawings illustrating it, happened to be faithfully copied by Shaw in his General Zoology,[4] on the ground that "a further illustration of so curious a subject cannot but be acceptable to every naturalist."

According to Shaw's copy, the figures, lettered A to D, are quaint, uncompromising images of a little, big-headed monkey with round eyes, large ears, long stiff hairs about the brow and the mouth, and a long, slender and flaccid tail. Figure D is the one reproduced by Petiver and Schreber. The description by Kamel, who names the animal "*Magu*, sive *boot* Indorum," runs as follows:

> Magnitudinem, quæ Gliris est, icon exprimit, et communiter adhuc minor, et gracilior est. Facies leonina: oculi rubri, magni, rotundi, ut noctuæ, nunquam aut raro conniventes: aures pellucidæ, depiles. Pilus murium luteolus aut aureolus. Gesticulationes lepidæ ut Simiæ. Cauda et pedes posterius longitudinis reliqui corporis. Raro interdiu apparet, hinc eum cæcutire putant. Progreditur ordinariè saltando, et restrorsum vel in obliquum velocius quam antrorsum. Narrant vivere carbone, &c. sed falsum est, cum ficu Indica, et aliis vescatur fructibus.

The following short explanation of the figures is appended to this description:

> L. *A* sedens, et comedens, ut Simius dextra.
> *B* arborem scandens.
> *C* sedens et terrens, cum timet.
> *D* incedens cum prole, quam ad ventrem, plantæ volubilis *Pamago* funiculis, alligatam sugientem gerit. *Pamago* vero Indi ad recidivas commendant.

In trying to identify the animal to which these descriptions and figures refer, attention must be drawn to the first native name used by Kamel, "magu," "mago" or "magou" being the Philippine vernacular for *Tarsius*. And, indeed, the foregoing account is so clearly referable to *Tarsius*, that previous failings in the identification of the problematic species can be only ascribed either to complete lack of knowledge of

[4] Vol. I, part I, p. 68.

Kamel's description or, as in the case of Shaw, to the fact that *Tarsius* was not generally known to be a Philippine animal till a comparatively recent date. The small size, compared to that of the common dormouse, the red, large and round eyes "like those of an owl," the nude and translucent ears, and the long hind legs, as long as the rest of the body, are truly peculiar characters, a better description of the tarsier being hardly to be expected if the date at which Kamel wrote is considered. The missionary's remark "narrant vivere carbone" is also interesting, as the same native belief has been recorded for the Philippine *Tarsius* both by Whitehead and by Heude.[5]

The drawings of the animal by Kamel are certainly not very fair representations of the tarsier, but, since it is said that they are life size, it is utterly impossible to refer them to the Philippine macaque or to any other East Indian monkey, whereas from the locality it would be absurd to see them as figures of a New World species. Unfortunately, the figure copied by Petiver, and later by Schreber, was not the more natural, but the more quaint one. Figure B, showing the animal "arborem scandens," bears a very curious resemblance to the photograph of a tarsier recently given by Elliot Smith.[6] I think Kamel's drawings were very probably done from memory, and may be intended to give a general idea of the animal rather than its detailed characteristics.

As for the locality, the fact that *Tarsius* has not been recorded from Luzon by modern authors has no importance at all, this animal being common in Samar, near the southern part of the larger island, and being sometimes carried there for sale by the natives.

My conclusion is, therefore, that the animal described by Kamel, and on which *Simia syrichta* was based by Linnæus, is nothing but the common Philippine tarsier. As a consequence, and according to priority laws, *Tarsius philippensis* Meyer must give way to *Tarsius syrichtus* (Linn.). And it is, certainly, a curious fact, now when the systematic position of *Tarsius* and its relations to other primates are questions of the moment, to find that this animal has its place among the Linnæan species, having been known long before its assumed discovery by Buffon and Daubenton.

Madrid, Spain.

[5] See Elliot's Review Primates, I, p. 11; and III, p. 257.
[6] Proc. Zool. Soc. London, 1921, pl. I.

OBSERVATIONS ON A MONTANA BEAVER CANAL

By S. Stillman Berry

[*Plates 10–11*]

Less frequently seen than the spectacular dam and lodge, but, when in a state of perfection, well nigh exceeding either in the interest and wonder which it invariably arouses in the mind of one fortunate enough to encounter it, is the unique example of beaver engineering known as the canal. As familiarity with it increases, one rarely fails eventually to regard it as altogether the most astounding evidence afforded us of the beaver's extraordinary "capacity," as Willey puts it, "for suiting its labours to the nature of the district which it inhabits."[1] The attempt to explain it on the basis of hereditary instinct alone is not wholly convincing. The comparative rarity of the canals, at least in their more developed forms, only adds to the astonishment with which each new observer views so purposeful a conquest, through efforts both individual and coöperative, of difficulties which must, from the very nature of the case, be almost wholly peculiar, local, and therefore *original*. Not only is there nothing stereotyped about the construction of the canal, but, given even the closest possible parallelism in attendant circumstances, the answer to the question of whether a canal will be built or not is variable. In many regions where beavers are known to flourish, their haunts may be explored to the end of time without finding so much as a trace of an attempt at canal-building,[2] while elsewhere a colony situated under what would seem far less favorable conditions has laboriously constructed entire systems of these water works. Nor must the possibility be overlooked that different species or subspecies of beaver may not be possessed of the same natural capacities in this direction.

The entire phenomenon of canal-building by beavers is surely worthy of a far more intensive study by observers trained in modern methods of the investigation of animal behavior than has yet been given it. When such sporadic observations as the few which have been made include so much of more than ordinary interest, a genuinely exhaustive

[1] Yet Lydekker, in the article "Beaver" in the 11th edition of the Encyclopædia Britannica, fails even to mention the existence of the canals.

[2] It must be admitted that lodges, too, are in some places conspicuous only for their absence, while some colonies have so forsaken more usual habits as temporarily at least to have given up even dam-building.

investigation could hardly fail being fruitful. It is because prior to so desirable a consummation even relatively minor contributions may prove of interest, that these notes are offered. At least one basal fact seems to be pretty thoroughly established: these artificial waterways are constructed primarily for the transportation of food, thus bearing an analogy to the more pretentious canals of human construction, and, like the latter, they appear to be only secondarily utilized for the transportation of building materials, for the diversion of needed or superfluous water, or as simple thoroughfares for the beavers themselves. I would not deny that there are sometimes individual canals which situation or other circumstances quite conclusively indicate to have been intended largely or wholly for one or the other ordinarily subsidiary purposes last mentioned. Indeed several such examples have been cited by Mills,[3] in a volume which contains quite the best account of this phase of beaver activity that I have been fortunate enough to encounter. But this does not gainsay that the primal urge back of all this cerebral activity, whether or not any degree of intelligent control of the instinct be admitted, is that of food getting.

The aspen, or quaking asp (*Populus tremuloides* Michx.), is said to be the tree the bark of which is most keenly sought for by the beaver as food but. in the absence of the aspen, various other species of the Salicaceæ, notably certain of the cottonwoods and willows, with perhaps one or two other trees, seem to serve just as well. However that may be, once the supply immediately adjacent to the winter feeding basin has become depleted, the simplest recourse (for the beaver) is to push his foray farther afield, and, as his most faithful admirers admit him to be far more agile and dexterous in water than on land, what more natural when he wishes to take advantage of a slightly more distant forage plot than that he attempt to carry his medium thither with him!

For the past five years the writer has had under intermittent observation a very long and in some ways unusually highly developed beaver canal which is the subject of the following account. It is situated on the Winnecook Ranch, one of the old-time stock ranches still persisting, a few miles east of Harlowton, Montana. Therefore some degree of protection of both the canal and its architects has been possible during a part, if unfortunately not the entirety, of the period of observation. More generally the location may be stated as Wheatland

[3] Enos A. Mills, In Beaver World, pp. 77, 103, 106–107, 145, 149 (1913).

County, south-central Montana, whereof the principal body of water is the Musselshell River, a considerable stream traversing the entire county in a west to east direction, and inhabited, at any rate in favored stretches, by colonies of the beaver.[4] The more striking physiographic features of the river and its immediate environs are fairly constant throughout this area. The prevailing bench lands of the north, and the rougher and more broken hills to the south, as in all our upper prairie country, terrace down to a sharply defined, narrow, and comparatively level "bottom," through which meanders, though frequently with considerable current, the river itself on its way to join the muddy torrent of the great Missouri. The only "forest" is an irregular, yet generally abundant growth of cottonwood trees (*Populus*, spp.), in their primeval state all intertangled with a thick undergrowth, "the brush," composed of such smaller trees and shrubs as willows of divers species, buffalo berry (*Lepargyrea argentea* Nutt.), chokecherry, dogwood (*Cornus stolonifera* Michx.), wild roses, currants, gooseberries, and other associated types, which borders the actual stream channel, forming a continuous belt of an eighth to a half mile in width, but giving way here and there to more open park-like spaces, or long swales or sloughs. In spite of the encroachments of civilization and a relentless persecution at the hands of farmers and less legitimate foes, which have combined in so many regions to force the beaver to surrender all his more characteristic and conspicuous ways of life or be exterminated, in many a serene nook along the Musselshell his lodges, dams, trails, slides, food piles, abandoned stumpage,—indeed, his own picturesque self, are still to be observed in something like their original perfection. And since this particular race of beaver seems to be especially addicted to building canals, these are by no means lacking.

The particular waterway in question is by all odds the finest specimen of this type of work which has been discovered in this neighborhood. Just above the point where the canal becomes tributary to the river, the Musselshell is quite deep in places, even at the lowest water. Slides, tracks, peeled twigs, food piles, and other evidences of beaver occupation have long been numerous there and I have little doubt but that somewhere hereabout is the principal home, or at least the site of the parent colony, of the beavers who built the canal.

[4] I am not aware that the specific determination of the beavers inhabiting the Musselshell and its tributaries has ever been made. The present locality seems to be rather close to the supposed boundary between the ranges of *Castor canadensis* and *C. frondator*.

The river wanders much through this part of its course, and in the not distant past has veered and shifted and migrated so that the cottonwood forest springing up along its successive beds has produced an unusually broad piece of woodland at this point, especially to the south of the present course of the river, and there are many of the little open parks, twisting lines of trees marking former channels, shallow depressions, and narrow swales bordered by willow thickets. Straight back into this native tangle the beavers have found occasion to build their canal. Although one of the best traveled ranch roads of the time led through a large park immediately west of the canal, while not a great way to the east was a much-used sheep shed, so swiftly and unobtrusively did the beavers carry out their work when once engaged upon it, that in the spring of 1916, when one of the ranch boys happened to stumble into it, the canal had been completed, we know not for how long previously, and was being abundantly utilized. There are two reasons for believing that at this time the canal of a fact had not been in existence so very long. In the first place, when discovered it was at the very acme of structural perfection, in fact was so finished in detail and so well kept that some of those who first saw it had no thought of it as possibly of other than human origin, and expressed a wonder as to who could be running so well constructed an irrigation ditch through that particular piece of forsaken jungle, and more especially how it could have been constructed without their knowing it. In the second place, when the present writer first visited the canal, on the succeeding 29th of July to be exact, the principal tree fellings adjacent to the middle and upper reaches of the canal were in the main quite fresh. Many fellings were in progress at the time and similar work continued all through that summer. The canal was revisited a number of times that season and likewise during the summer following by the writer and others, but it was not until August 25, 1918, that it was thoroughly explored, its real extent appreciated, and the entire system as carefully measured and plotted as was feasible in the absence of a surveying equipment. Most of the notes forming the principal basis of the present account likewise date from that time.

The general trend of the canal together with its succession of contributory works is practically south to north. Principally as a direct result of disturbing variations in the character of the terrain which it traverses, the system is composed of several very differently constructed segments. Since so far as the watercourse proper is concerned these segments chanced to coincide almost exactly in extent with the three

principal curves, it becomes convenient to resort to a correspondingly arranged treatment for its description. A glance at the accompanying diagram now and then will be helpful in rendering this point and much of the remainder of the discussion clearer.

The first or lower segment comprises, or rather did comprise, the main canal, leading in the form of a crescent from the river into a long slough curved in the reverse direction, which was utilized as the second segment of the canal and only here and there exhibits evidence of artificial treatment by the beavers. The third segment is made up of a much narrower canal which passes by way of an ephemeral rivulet into a mere beaten trail which finally loses itself in the undergrowth, some 1145 feet, measured by the canal, from where the latter left the river.

The first-mentioned division of these extensive works, therefore, is readily seen to be the one of primary importance and interest. The terrain here not only offered certain special advantages for the construction of such a work, but at the same time certain noteworthy difficulties, all of which seem to have been taken advantage of or overcome, as the case chanced to be, in quite a remarkable manner. A little way back from the river and separated therefrom by a low, willow-covered ridge, is a narrow swamp, no doubt originally a prolongation of the large slough mentioned in the last paragraph as constituting the second principal segment of the water course. Students of beaver bionomics have more than once called attention to the interesting aptitude exhibited by the animals in carrying a canal across a slope by banking the excavated earth largely or wholly on the down side.[5] In the present instance a complication enters in, the mastering of which has resulted in perhaps the most interesting single claim to novelty which this particular canal possesses. For in order to bring about the desired connection between the flooded slough and the river the beavers had not only to pierce the low, willow-clad ridge near the river, but in some way to carry their water course across the depression occupied by the miry swale. By felling and removing innumerable willows they might have accomplished this in the usual manner followed in crossing a simple slope, running the canal along the bank of the swale and banking it on the down side only, but this would have necessitated an enormous amount of labor. There was a better way to solve the problem, a way which any irrigation engineer would have chosen under the pressure of similar circumstances, and this was chosen by the beavers. They ploughed their channel right through the center of the

[5] e.g., Mills: In Beaver World, p. 88.

swale and *banked both sides* of the canal. In 1916, when the work was new, the *levees* so constructed were very conspicuous, and sufficiently high to enable the beaver to fill the canal to a level appreciably higher than that of much of the immediately adjacent terrain. In winter these levees gave rise to an especially curious effect at times, for when the snow receded they were exposed first and showed as two narrow parallel ridges protruding through the white mantle covering the canal and the surface of the swale. Beginning exactly at the lower end of the flooded slough, though a little to the northeast of the center thereof, the levees featured the canal for a distance of some 215 feet. In fact this entire lower portion of the canal was very regular and as exact in construction as rather careful human hands would likely have made it.

Although I speak of the canal as opening *into* the river, I never was able to determine which end was actually the head and which the foot of the main portion. When I first saw it in July, 1916, all the water was out of it except a mere trickle which drained into the river. There were plenty of fresh beaver tracks in the muddy bottom and those of white-tail deer, coyotes, wild-cats, and a few smaller animals along the levees. In 1918 it was full, or nearly full, of water, which was slowly flowing *away* from the river and into the slough. That same summer a little later I saw the water in the canal so nearly neutral between river and slough that floating particles moved now one way, now the other, in the most indeterminate fashion. Sometimes the water was noted to be flowing steadily toward the river. The obvious explanation of this curious state of affairs would seem to be that this part of the canal was so nearly level that the direction of whatever current manifested itself depended wholly upon the relative levels of the water in river and slough. But in practice the problem failed to resolve itself so simply, and I have sometimes been quite at a loss to explain a given reversal in the direction of flow. With the river at fair flood I have found the entire beaver works nearly empty, while the last time I saw the canal with any head of water it was setting distinctly in the direction of the slough although it was the last of August and the Musselshell was in its season of low ebb. It is possible that the condition of the big slough is a more important consideration for the behavior of the water in the lower canal than that of the river. When the Musselshell is low the river end of the canal is necessarily high and dry, and at such a season the slough also is apt to be reduced to a mere quagmire. Measurements taken in the latter part of the month of August, 1918, showed that near the main bend (x————x in the accompanying diagram)

FIG. 1. DIAGRAM OF THE BIG BEAVER CANAL AT WINNECOOK, MONTANA, TOGETHER WITH THE MORE IMPORTANT OF THE BEAVER WORKS TRIBUTARY TO IT, AS THEY EXISTED IN AUGUST, 1918

the canal had a low water diameter of 5 feet, or of 9 feet 6 inches measured across the summits of the levees at the same point. At the mouth it was 9 feet in diameter (8 feet at water level), with a maximum depth of 1 foot 8 inches and a low water depth of 10 inches. Where it cut through the willow bank (y————y of diagram) the canal diameter at high water level was 6 feet 9 inches; at low water level 5 feet 6 inches. The low water depth at this point was 1 foot to 1 foot 3 inches. The river near the mouth of the canal was about 50 feet wide at this time. At the date of these measurements the leveed part of the canal had already begun to deteriorate badly. The banks were partially worn down and the hollows in the swale largely filled in by the washings, but still in some places, especially on the lower or east side, the banks remained to some extent leveed above the adjoining ground. It would appear that in its pristine condition, upon emerging from the willow clad ridge, the canal opened directly into the river very nearly at right angles with the shore line, or even deflected to head a trifle up-stream. But a heavy mudbank was later silted across it by the river current so persistently that after a little effort to keep open an adequate passage across it, the beavers capitulated and sheared away the shore to the east a little in such a way as to run their channel down stream back of the bar, across the foot of which it then opened obliquely into the river without much danger of further blocking. Up to this time there were no dams of the beavers' own making either at the river opening of the canal or at its juncture with the flooded slough, or, in fact, at any point between.

In 1918, and at certain times previously, the slough at the head of the leveed canal was a turbid lake some 260 feet long and 40 feet across, bordered, like the swale at its foot, by a thick growth of scrub willows, wild roses, and a few dogwoods, with cottonwoods of two species rising farther back. Many of the willows and cottonwoods, particularly at the upper end of the slough, had been felled, numerous slides on the steep east bank and trails leading through the growth of willows to both east and west yielding abundant testimony of the activity and industry of the rodent woodsmen. There was also evidence of the floating of considerable quantities of felled timber via the slough into the canal and thence to the river. The attainment of this inland timber was of course the principal motive for the building of the canal, although the beavers seem to have made the flooded slough the domicile of a part of the colony at this time.

But a further quantity of very desirable willow and cottonwood growth still existed farther up between the slough and the hills. I had

previously noticed beaver cuttings as far beyond the slough as the road-crossing on numberless occasions, but had never thought to associate them with the beavers of the canal, nor to explore the upper end of the slough, at any rate until August, 1918. At that time I traversed the entire length of the slough in order to measure it, and was quite unprepared to discover thereupon in the willow tangle at its head a continuing canal leading on to the south through the dense thicket. The ground here was marshy and many little side canals had been pushed off into the willows toward the firmer ground on either side. This canal was neither so ambitious in magnitude nor in any respect so finished in construction as the lower one. A narrow, pebbly creek bed of some former time, hardly more than a foot in width, underlay its upper reaches, uncovered where the beavers had pushed back the swampy mire which had engulfed it. The flooded part of the canal did not quite reach this point when I saw it, but there was evidence that at no very distant time the water course had extended considerably farther. Perhaps a hundred feet farther on even the pebbly creek bed became indistinct where it traversed an open marsh, but beyond this it emerged once more and the trail continued to follow it very plainly to an old beaver slough another hundred feet in length, with felled trees and other beaver signs all about. At this time all these relics were more or less weatherworn and very fresh indications of beaver activity were quite wanting. Above this last small slough, it was still possible to follow the main trail for perhaps yet another hundred feet. But here it constantly grew fainter and finally lost itself entirely about where the road crosses through the little break in the woods where the beaver cuttings had first been observed.

As there is some evidence that the beavers themselves have at times been responsible for the flooding of the big slough, and they have actually excavated its bottom in places in line with or even in continuation of the upper and lower canals, it seems only just to reckon the entire length of the water course, or 745 feet, as that of the canal. So credited, it becomes one of the longest which has been recorded.[6]

[6] Seton (Life Histories of Northern Animals, vol. 1, p. 458) records a beaver canal at Gal Pond, in the Adirondacks, 654 feet long and some 4 feet wide, leading "from the pond to a grove of poplar and yellow birch." "Although abandoned for fully fifty years it was very well marked and showed many Beaver cuttings." Most of Seton's discussion of beaver canals is, however, taken from Morgan.

Mills (In Beaver World, p. 140-141) describes and illustrates a remarkable canal near Long's Peak, Colorado, which was excavated through a deep wreckage of fire-killed and fallen spruces in order to permit the successful harvest of a

The canal has now been under observation as opportunity has presented for six summers, and I have also been able to pay it a winter visit or two. As has been related the canal was in its highest state of perfection in July and August of 1916. A year later it had been somewhat damaged by the abnormally high water of that season and although it continued to be occupied it was never fully restored. In July of 1918 I found it very miry and in bad shape in other particulars, but the beavers were still actively utilizing it and did a little work on it during the rest of that summer. A miserably cruel and needless onslaught carried on against them by persons who chanced to be temporarily connected with the operations of the ranch along about this time so depleted their numbers that until quite recently it was feared it would be many years before the damage could be made good. Certainly the canal showed the effect of this slaughter, for in 1919, which was a year of almost unprecedented drought and low water when they would normally have been exceedingly assiduous in storing back as great a proportion of the retreating waters as possible, the entire canal was absolutely dry, pond and all, and badly grown to rushes and weeds. No evidence whatever of renewal of beaver activity anywhere along the canal was detected either that summer or the next. In fact by August of 1920 the unoccupied canal, still nearly dry, had been washed in at the sides all along the line, and the lower canal as well as even part of the former pond were almost completely smothered in the rank growth of rushes, sedges, arrow-weed, marsh grass, and similar plants, which had overgrown them.

Meanwhile there was put into effect on the part of the ranch management a more enlightened and forward-looking policy respecting the care of such wild creatures as still remained within the bounds of its jurisdiction. Hopeful that the beaver in particular would eventually respond to the more sympathetic treatment, I nevertheless was completely taken by surprise, upon revisiting the old canal in August, 1921, to find there already indubitable evidence of their resumption of

certain grove of aspens. This canal was 334 feet long, with an average depth of 15 inches, and a width of 26 inches. Still more noteworthy is the very complex canal which he observed near Three Forks, Montana (op. cit., p. 107–111, fig.), and which had a total length of 428 feet.

By far the longest canal recorded by this author was observed at Lily Lake, Colorado (op. cit., p. 104, ill. opp. p. 102). This canal was one of a number built by the beavers of the local colony in order to maintain necessary water thoroughfares in the bed of their home lake during a time of drouth. It was measured to be 750 feet long, 3 feet deep throughout, and from 3 to 5 feet wide.

domain. The pond had not been again flooded, nor did I notice any fresh beaver work near the road crossing or in visited portions of the intermediate area, but the lower segment of the canal showed a narrow median strip which had been dredged clear of weeds and basined out, and had evidently lately carried a flow of water, although for the time being it contained none. The extreme lower part of the canal adjacent to the river still retained approximately its original dimensions with the weeds only slightly encroaching at the sides. The mud bar still persisted, but strangely enough it had been cut through once more and the original opening of the canal approximately restored. But the halcyon days of the leveed portion were no more. The old high banks were merged in the surface of the swale, and the newly excavated tract in the middle had a bottom width of but 10 to 15 inches, a high water diameter of but 15 to 30 inches, and a maximum depth of not exceeding 4 to 5 inches. Even worse, across the canal, about 30 feet above the mud bar, had been thrown a massive dam of well-packed mud and sticks, so inordinately high in relation to the usual water line of the old canal as to suggest very forcibly that it could be intended not so much to keep the canal from draining out, as to keep the flood of the river (at high water) from pouring in. Just a little down river the steep bank on the same side of the canal showed several holes and fresh slides. It is much to be hoped that the construction of the dam does not signify a final desertion of the canal, but that the activity of this colony of beavers will soon be pushed to the accomplishment of perhaps yet more interesting results.[7]

The linear measurements of the canal and its contributory works as they existed in August, 1918, are summarized in the following table:

Leveed portion of lower canal	215 ft.	
Gross length of lower canal	285 ft.	
Length of flooded slough	260 ft.	
Approximate length of upper canal	200 ft.	
Total length of water course		745 ft.
Approximate length of former water course and its trail-like continuation		400 ft.
Total length of entire system of works from river to head		1,145 ft.

[7] Since this paper was submitted for publication the intervention of another summer enables me to add that upon a visit to the canal in September, 1922, we found its desertion apparently complete; this in spite of abundant beaver sign in the neighboring stretches of river.

EXPLANATION OF PLATES

PLATE 10

Upper figure.—The main canal as it appeared when first discovered; looking toward the river from a point on the big bend about 160 feet from the mouth of the canal. Photograph by the author, July 29, 1916.

Middle figure.—The main canal after the wearing down of the levees, taken looking toward the river from a point around the bend to the south. Photograph by the author, August 25, 1918.

Lower figure.—The long slough from its north end, showing emergence of the beaver canal in the fore part of the picture. The dense growth of cottonwoods and willows in the background has been the scene of much beaver activity during the occupancy of the slough and canal. Photograph by the author, August 25, 1918.

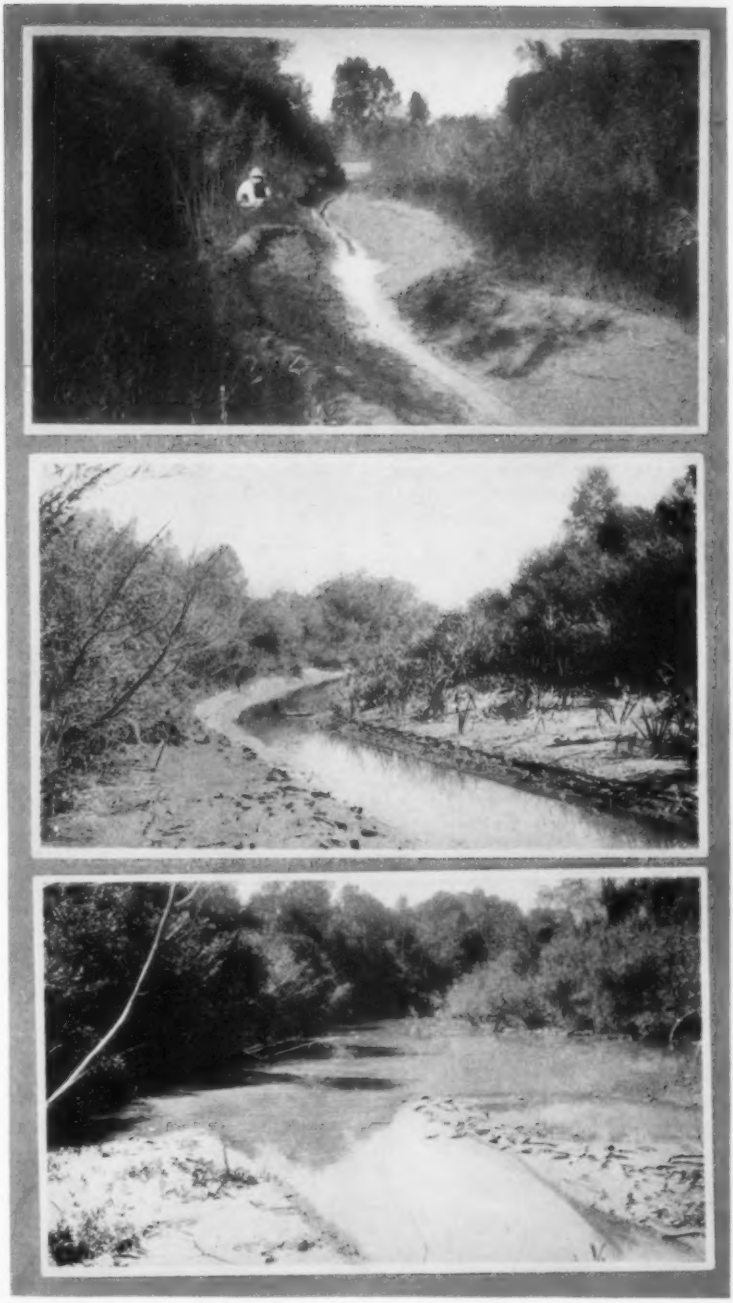
PLATE 11

Upper figure.—The northern extremity of the canal where it pierces the willow clad ridge before entering the river. Photograph by the author, August 25, 1918.

Middle figure.—The junction of the canal with the Musselshell River, the canal itself being somewhat obscured by the bar silted across its mouth. Photograph by A. W. Bell, August 25, 1918.

Lower figure.—Looking north along the main canal in 1921, showing the results of the first efforts of the beavers to clear away the rushes and other growth which had engulfed the old canal. View similar to middle figure of Plate 10. Photograph by the author, August 10, 1921.

Redlands, California.



A Montana Beaver Canal

(Berry: A Montana Beaver Canal)

A Montana Beaver Canal

(Berry: A Montana Beaver Canal)

AQUATIC HABITS OF THE WOODCHUCK

By Charles Eugene Johnson

So far as I have been able to learn the woodchuck is commonly believed to avoid entering the water. Seton, in his Life Histories of Northern Animals, with regard to this question, says: "In the water, from all accounts, the woodchuck is far from being at home. It can swim, but poorly, and wisely eschews the element where it is at such a disadvantage."

Having, on two occasions, witnessed voluntarily undertaken swims on the part of the woodchuck, I was led to make a search of available literature for possible records. The only instance I have succeeded in finding is the following interesting account by Dr. C. Hart Merriam, in his book, Mammals of the Adirondacks, 1886:

> Having searched in vain for the record of an instance where a Woodchuck has been known to swim, voluntarily, I take great pleasure in being able to contribute an account of a case that recently fell under my personal observation. On the 12th of June, 1883, while rowing up the Fulton Chain of Lakes, in company with Dr. A. K. Fisher and Walter H. Merriam, a Woodchuck was observed in the water directly ahead of the boat, swimming across the channel between Second and Third Lakes. He swam deep, at times the top of his head and the tip of his tail alone appearing above the surface. He crossed from the north to the south shore and was evidently very much fatigued and somewhat confused, for although I pushed the boat close after him as he was about to emerge, he only partly climbed out upon a small log that extended into the water, and showed no inclination to move off, or even to change his position. He was poked several times with a stick, and finally Dr. Fisher actually stroked him with his hand before he became sufficiently aroused to show that he was aware of our presence. We left him standing partly upon the log, with one leg still in the water, shivering, and apparently in a very unhappy state of mind. This animal was young, and was evidently travelling about in search of a suitable place in which to establish his home.

Of the two instances which I have personally to record, the first occurred on an afternoon in August, 1913, in northern Lake County, Minnesota.

According to my field notes, while my two companions, H. N. Hanson and R. N. Chapman, and myself were quietly occupied about our camp, at the rapids of the Isabella River, near Lake Bald Eagle, my attention was attracted by a small black animal moving about at the edge of the water on the bank across from our camp. Cautiously we walked down to some boulders near the water and then saw that the animal was a melanistic specimen of the woodchuck. From its actions it was ap-

parent that it was preparing to cross to our side of the river which at this point is the lower end of a long rapids, has a width of about fifty feet, a depth of two to three feet, and a swift current.

Although we moved very slowly and cautiously down to the bank we were all the time in plain view of the woodchuck, but the animal was so preoccupied in trying to find a satisfactory jumping-off place that our presence appeared entirely unnoticed. The short distance gave us an excellent view and we sat down to await developments. The woodchuck ran back and forth on some partly submerged rocks at the edge of which the water was swirling past. Repeatedly it would run to the edge of a rock, lift its head and sniff towards the opposite bank; then resolutely gather its legs under it and appear about to make a spring—only to check itself suddenly, as if at the supreme moment it lost its nerve at the sight of the turbulent water before it. Then it would run to another rock, repeat its preparations, and again draw back before a gush of water no more inviting than the last. But its movements were quick and determined and there was not the slightest doubt that in a few moments it would make the plunge. We could not help marveling that it should choose such a swift and unfavorable crossing place when much calmer though wider water could be found about a hundred feet farther down stream. However, the period of indecision was actually of short duration, probably not more than two or three minutes at most. Running out to the edge of one of the same rocks that it had tried before, the animal plunged in, directly towards us. The swift water carried it rapidly down stream but it kept heading across the current, swimming strongly and well. A number of times it was tossed by the rough water and once or twice momentarily almost lost to view. It reached our shore probably fifty feet below its starting point, landing on some projecting rocks behind our canoe where we managed to get a snapshot of it with our camera. Soon afterward it scampered into the woods, directly toward a burrow under the roots of a big pine near by and entered it with all the familiarity of an owner.

I was much impressed by what I had witnessed and in my own mind wondered how many small dogs, unaccustomed to the water, could have been coaxed to swim the river at this particular point.

The second instance occurred near Lawrence, Kansas, on June 3, 1921. While my wife and I were sitting on the high bank of Wakarusa Creek, three miles south of here, at half past two o'clock in the afternoon, a large woodchuck swam leisurely across the creek about a hundred yards above us. It swam easily, with all of its dorsal surface as far

as the rump out of water. With a pair of 6-power field glasses we watched it until it hauled out on the opposite bank. The part of its body that had been submerged and its tail were thoroughly wet, the hair pasted to its body, sharply contrasting the lower part of the animal with the dry, fluffy upper part. After landing the woodchuck walked slowly and unconcernedly up the bank a few feet when it was lost to view in the tall weeds. It did not shake itself during the time that we could see it. The day was cloudy and the temperature about 70 degrees. The creek at this place is about seventy-five feet wide, with slight current, and on this day there was scarcely a ripple on the surface.

Along this creek woodchucks are common, on both banks, and it is my opinion that individuals swim across from one side to the other more frequently than may be supposed, but the woodchuck is both shy and alert and it is only by good fortune that one may sometimes catch it in the act; it requires first of all a "clear coast."

Department of Zoology, University of Kansas, Lawrence, Kan.

NOTES ON SOME MAMMALS OF RILEY COUNTY, KANSAS

By Lee Raymond Dice

The following notes were secured between February, 1916, and September, 1917, while I was serving as assistant zoölogist in the Kansas State Agricultural Experiment Station. Most of the work of trapping for the small mammals was carried on by Mr. E. A. Herr, who trapped extensively in the vicinity of Manhattan, Riley County, Kansas. Owing to numerous other duties we did not preserve many specimens, and the subspecific names employed are based mostly on geographic probabilities. Prof. G. A. Dean has contributed a number of notes on the distribution of the larger mammals. Descriptions of the habitats of the region have been published in Ecology (vol. 4, pp. 40–53).

Didelphis virginiana virginiana. Opossum.—A strictly woodland form, though I have no precise habitat records from the region.

Scalopus aquaticus machrinoides. Missouri Valley Mole.—Common in meadows, on the campus, and on the lawns of the city of Manhattan; numerous in the elm-oak forest along Wild Cat Creek and in the thickets on the hillsides; absent from the upland prairies, though ridges sometimes extend for a number of yards from the thickets into the prairie. At a time of melting snow, when the

lower ground was partly flooded, several were found on the surface of the ground on the campus; I have dates of February 9, 12, and 17, 1916. In the evening of July 9, 1917, an adult male was found on top the ground at the edge of a street in Manhattan.

Captives could not be kept alive more than a few days. While alive they seemed fond of earthworms and beetle larvæ. The food seemed to be located entirely by the senses of smell and touch. Earthworms were located by smell and seemed always to be seized at the end. If first touched in the middle by the proboscis the worm was always rapidly followed to an end before being seized. The proboscis was much used in moving the food about to get it into position to be taken into the mouth. All food seemed to be carefully chewed; one could distinctly hear the grinding of the teeth when the animal ate earthworms.

On a hard surface most of the under surface of the body seems to rest on the substratum, although at times the body is slightly raised on the feet; the body is forced forward sometimes by both fore feet and both hind feet working at the same time, while at other times the feet of the opposite sides of the body were used alternately. The animal readily backs up or turns around. For exploring a passage the proboscis is used and even at times the tongue is extended, if the proboscis will not go, as through the meshes of the screen on the cage. In loose ground or sand the animal makes rapid progress, quickly opening a passage with the spade-like fore feet, which are brought forward alongside the nose and forced outward.

Blarina brevicauda brevicauda. Bob-tailed Shrew.—During July, 1917, one was taken in a thick growth of herbs along a slough on the Kansas River; six in a thick growth of small tree willows with many herbs near the same place; three in a damp place in a heavy elm-oak forest; two in a shrubby thicket; and one in a growth of sumac without rocks.

February 7, 1916, some students caught one on the campus, as she was running on top the snow, about 3:30 p.m. When put into a glass dish she made persistent efforts to escape, chewing repeatedly on a bit of cotton rag holding up the glass cover. When running the body was held close to the ground with the feet outward; the tail usually touched the ground for the last two-thirds of its length; and there was often a pronounced hump in the back near or posterior to its middle.

A female taken July 17, 1917, contained 4 embryos of 2.5 mm. length, while two other females taken July 13 and July 19, respectively, contained no embryos. The weights of six adult males taken in July averaged 13.0 (11.0–15.5) grams; and three females weighed respectively, 12.0 (with four embryos), 14.5, and 17.0 grams.

Canis nubilis. Wolf.—Extinct in the region.

Canis nebrascensis nebrascensis. Coyote.—One was seen in a sumac thicket and another on the upland prairie. Coyotes are reported to be most abundant on the open, rocky slopes of the hills.

Vulpes sp. Red Fox.—Red foxes are said by Professor Dean to occur on the prairie and possibly also in the timber.

Procyon lotor lotor. Raccoon.—In July, 1917, tracks were seen by Dr. R. K. Nabours at the edge of a slough. Raccoons are reported by Professor Dean to occur in the timber along the streams.

Mustela longicauda longicauda. Weasel.—Weasels occur in the timber, but I have no records of exact habitats.

Mustela vison letifera. Mink.—Reported from along the streams and adjacent forest.

Spilogale interrupta. Prairie Spotted Skunk.—Professor Dean reports it to be common on the prairie, in the meadows, and in the timber.

Mephitis mesomelas varians. Long-tailed Texas Skunk.—One was seen at the edge of a thicket by some members of the zoology faculty. These animals are reported to occur also on the prairie and in the timber.

Taxidea taxus taxus. Badger.—Formerly occurred on the prairie, but there are no recent records.

Reithrodontomys sp. Harvest-mouse.—Two forms of harvest-mice might occur in the region: *R. albescens griseus* and *R. megalotis dychei*. No specimens were preserved, and it was discovered near the end of the field work that the field characters relied upon would not separate the two forms. I am unable to say which form was taken or whether both were present.

Harvest-mice were abundant throughout the year on the prairies of the hills, where 18 in all were taken; during May, 1917, two were trapped in high grass among rocks on a steep hillside; and in July one was taken in a grass and sedge meadow in the bottom of a small valley. In July, ten were taken in a thick growth of herbs in the bed of an old slough along the Kansas River, and two were trapped in a thick growth of tree-willows at the same place. Embryos: May 2, 1917, 4; July 19, 4; July 20, 3.

Peromyscus maniculatus bairdii. Prairie Deer-mouse.—Common on the prairie and on rocky ground; and numerous among the sumac scrub, especially where this is growing on rocky slopes. During November, 1916, when the leaves were off the trees, two were trapped in oak forest at the head of a ravine, not far from a rocky slope. Forty-nine individuals in all were taken. May 12, 1917, a male and a female were found together in a small nest of dry grass under a rock on a steep hillside. Eight adult females taken July 27–28 on a rocky slope averaged 13.2 (11–15) grams; and 5 adult males, averaged 16.7 (15–20) grams.

Peromyscus leucopus noveboracensis. Forest Deer-mouse.—Abundant throughout the timber and extending out into the thickets and scrub sumac. In July, 1917, it was common in a thick growth of herbs on moist ground along a slough of the Kansas River, the herbs not extending more than about 15 yards from the forest in any place. In July, also, three were trapped in a narrow strip of meadow in the Kansas Valley, not over ten yards from a growth of willows. In May, four were trapped in thick grass on a rocky slope not far above the forest of Wild Cat Creek, and July 27 one was taken in thick weeds on a rocky slope on Prospect Hill, more than one hundred yards from the nearest shrubs. In all 158 were taken. These records indicate that the species sometimes wanders a slight distance away from the woods which are its natural habitat. None were taken on the prairie.

Females containing embryos were noted May 23, May 24, and July 21, 1917, there being four embryos in each case. Fifty-two adult males averaged 25.3 (18 to 34) grams in weight, and fifteen adult females without embryos averaged the same, 25.3 (20 to 32) grams.

Neotoma floridana baileyi. Bailey Wood-rat.—April 7, 1916, two young with eyes still closed were found in a thicket on a farm near Manhattan. Their measurements were: length, 177 and 162 mm.; tail, 60 and 55; foot, 31 and 29; weight,

47 and 45 grams, respectively. A female taken July 7, 1917, in a thicket at the head of a ravine contained two large embryos. Another female taken July 11 in chestnut-oak forest on a hillside, contained no embryos, but the mammæ indicated that she was suckling young. This individual and another one were taken beside a nest of sticks heaped up among some large rocks. Two individuals were taken in July beside a pile of wood in an elm-oak forest in the Kansas Valley.

Synaptomys helaletes gossii. Kansas Lemming-vole.—Three specimens were trapped July 6 and 7, 1917, in a thicket on Stag Hill. A female and a male, adults, measured respectively: length, 122, 116 mm.; tail vertebræ, 15, 16 mm.; hind foot, 19, 21 mm.; ear from notch, 11, 12 mm.; weight, 32.5, 37 grams. The female contained no embryos. The other male weighed 48 grams.

Microtus ochrogaster. Prairie Vole.—Sets of runways are numerous in the damper parts of the prairie hills, such as in the heads of little coves. Also, individuals not in runways were trapped in these coves, in open prairie, and in grassy meadows in the valleys during May and July, 1917. During July two were taken in a small thicket on a hillside, and one was taken from a thick growth of herbs along a slough of the Kansas River. April 28, 1917, one was trapped in a tunnel carrying heating pipes on the college campus. In all, 11 were taken.

A female taken May 2, 1917, contained seven embryos; and another taken July 4 contained three embryos nearly ready for birth.

Microtus nemoralis. Woodland vole.—One was taken May 11, 1917, in a heavy growth of nettles in elm-oak forest beside Wild Cat Creek; another was taken May 16 in tall grass on a rocky slope not far above the forest of Wild Cat Creek; and a third was secured July 8 in a thicket in a cove on Stag Hill.

The female taken May 11 contained no embryos, but the mammæ gave evidence of being suckled. The female taken May 16 contained two large embryos. The measurements of the female taken May 11 were: length, 140 mm.; tail vertebræ, 26; hind foot, 18.5; ear from notch, 11; weight, 37.5 grams.

Ondatra zibethica cinnamomina. Great Plains Muskrat.—Reported common in the streams and sloughs.

Rattus norvegicus. Brown Rat.—In July, 1917, one was trapped on the muddy shore of a slough of the Kansas River beside a growth of tree willows and poplars; one was taken in the willows and poplars at the same place; and another was taken in marshy sedges beside a tiny stream in a little valley. Throughout the year it is abundant about the barns and feeding pens of the Experiment Station and also occurs in the college buildings and in the buildings in the town.

Of the rats taken about the college buildings and the Experiment Station four adult females examined in February, 1917, contained no embryos; five adults examined in March contained no embryos; of five adults examined in April, two, taken April 13 and April 16, contained seven and eight embryos respectively; an adult taken May 1 contained 11 embryos, each 7 mm. in length; a female taken May 2 contained numerous very small embryos; and a female taken May 5 contained 12 embryos of a length of 1 mm.; three other adult females taken May 1 to 5 did not contain embryos.

Mus musculus musculus. House-mouse.—One was taken July 19, 1917, in a thick growth of herbs at the edge of a slough. It is common in buildings on the campus and in town.

Two adult females taken February 23 and 24, 1917, contained five and six embryos respectively; of three adult females examined in March, one taken

March 15 contained 5 embryos, and one taken March 27 contained 6 embryos; an adult taken April 10 contained an indeterminate number of embryos; of six adult females examined in May, one taken May 3 contained 9 embryos of a length of 7 mm., and one taken May 4 contained six embryos of a length of 1.0 mm.

Geomys bursarius. Prairie Pocket-gopher.—A few mounds of the pocket-gopher may be found on the native prairie, and they are more numerous in the moister meadows in the valleys. In cultivated fields, especially in alfalfa fields, they become excessively abundant; and a few occur on the lawns of city lots.

In fields where gophers are common their runways must often intersect, and it is probable that parts of the same burrow are used, on occasion, by a number of individuals. From burrows apparently isolated, but perhaps connected with other burrows by underground passages, we took three individuals from each of two different sets of workings. From the first set an individual of unknown sex was taken February 27, 1916, a male March 7, and a female March 10. From the second set of workings a female was taken April 4, 1917, another female April 5, and a male April 6. From another set of workings two males were taken April 1 and 5 respectively. There are records of two other isolated burrows from each of which two individuals were taken during April, but although one of these individuals in each case is known to have been a male the sex of the other is unknown. However, it is shown by the above records that more than one male and also more than one female, as well as both males and females, may occur in the same burrows within very short periods.

On two occasions in 1917 adult females were found moving about on top of the ground at night in the city of Manhattan. The first was found at dusk, crossing a cement sidewalk about 8 o'clock in the evening, May 18. The second was caught on a street at 10 o'clock, June 10. Of 18 females the heaviest, without embryos, weighed 265 grams, and of 20 males the heaviest weighed 452 grams.

Perognathus hispidus paradoxus. Kansas Pocket-mouse.—July 9, 1917, one was trapped in grass and exposed soil on the gentle slope of a small ravine near the top of Stag Hill; July 20 one was taken in a small strip of native meadow in the Kansas Valley, and July 27–28 five were taken in rocky ground on Prospect Hill, occurring both on a steep slope having many large rocks and a few yuccas and sumacs, and on a more gentle slope covered with small rocks and a thick growth of low herbs.

The female taken July 9, contained five embryos of a length of 13 mm. Two males taken July 27 and 28 weighed 27 and 25 grams respectively, and two females taken on the same days weighed 29 and 34 grams.

Citellus franklinii. Gray Ground-squirrel.—Professor Dean reports it to occur on the prairie.

Citellus tridecemlineatus tridecemlineatus. Striped Ground-squirrel.—Numerous on the prairie hills, two being trapped. A few occur on the lawn of the college campus, being often found not far from the buildings.

Sciurus carolinensis carolinensis. Gray-squirrel.—Occurs in the region, but I have no precise records.

Sciurus niger rufiventer. Fox-squirrel.—A few occur in the timbered areas.

Castor canadensis canadensis. Beaver.—Professor Dean reports evidences of its former presence along the Great Blue River.

Lepus townsendii campanius. White-tailed Jack-rabbit.—Reported to occur on the prairie.

Lepus californicus melanotis. Great Plains Jack-rabbit.—Is numerous on the prairie and invades the adjacent cultivated fields.

Sylvilagus floridanus mearnsii. Mearns Cottontail.—Numerous, occurring probably in all the habitats of the region except the aquatic, cut-bank, and aerial. Apparently most numerous in the thickets and at the edge of timber. In April and May, 1917, several had forms under large gooseberry bushes in the elm-oak forest beside Wild Cat Creek. Three adult males taken in late November, 1916, averaged 1198 (976 to 1374) grams in weight, and seven adult females taken at the same time averaged 1287 (1036 to 1322) grams.

Bison bison bison. American Bison.—Formerly occurred in the region.

University of Michigan, Ann Arbor, Mich.

AN UNUSUAL WAPITI HEAD

By William Rowan

[*Plate 12*]

The accompanying sketch of the head of a bull wapiti in his fifteenth year was made in the Assiniboine Park, Winnipeg, Manitoba, in 1919. The spread of the antlers that year was approximately five feet. I understand from Mr. G. Champion, general superintendent of the Public Parks Board, that the antlers were at their best in 1917 with a spread of 61½ inches. Even in 1911 this bull had an exceptionally fine head, but, although the spread was then already remarkable, the horns conformed more to the standard type. They then showed six points on the left side and seven on the right, the terminal tyne on this side bifurcating at the tip. I should be extremely grateful to readers of the Journal of Mammalogy if they could supply me with any authentic records of heads that surpass this one for spread. I have no doubt that such exist, but I have hitherto been unsuccessful in locating them.

The length of the beam, on which I unfortunately have no accurate information, is not well shown on the sketch owing to fore-shortening, but was, in the fall of 1919, at all events, at least equal to the spread. It was altogether an extraordinarily beautiful head and most years showed perfect symmetry.

This animal was captured wild in Manitoba in 1905, presumably at the age of about five months. He was mated for the last time in 1918 and was still evidently fertile, as a calf was born to his mate the following year. He was, however, already showing signs of senile decay and in 1920, owing to loss of teeth and semi-blindness, he was shot and buried.

University of Alberta, Edmonton, Canada.

AN UNUSUAL WAPITI HEAD

Assiniboine Park, Winnipeg, Manitoba, 1919. Spread 60 inches. Sketch by William Rowan. By Courtesy of the Fogg Art Museum of Harvard.

THE MAMMAL COLLECTIONS OF NORTH AMERICA

By A. Brazier Howell

Slightly more than a year ago, the writer addressed a letter to the editor of the Journal suggesting the desirability of compiling an annotated list of the mammal collections, both public and private, of North America. This suggestion met with the approbation of the editor, and of sundry friends with whom the matter was discussed, and accordingly a questionnaire was mailed to all those known to have collections of recent mammals, a partial list of whom was kindly furnished by Dr. E. W. Nelson, Bureau of Biological Survey. In addition, blanks were mailed to over one hundred other individuals and institutions that might possibly have small collections. From many, responses were prompt and enthusiastic, but others were apathetic, and reports were secured only with difficulty after further correspondence, and the end is not yet. On the whole, however, the proportion of replies to this questionnaire may be considered as much larger than is usually the case.

The value of such a list as was proposed lies largely in its thoroughness, but the writer has despaired of completeness, and it has been deemed better to submit the list as it now stands (April, 1922) than to delay further in the hope of rounding up possible laggards. In addition to the latter, there are undoubtedly a few collectors of whom I have been unable to learn. To furnish the information desired, it has been necessary for the larger museums to go to a deal of trouble, several days' labor having been thus spent in one or more cases, and my appreciation is correspondingly great to curators of such, as well as to all others who have furnished data.

The larger museums are relatively sufficient unto themselves as regards research material; but the smaller ones, as well as unattached individuals, are often handicapped by their inability to secure, either by purchase or loan, specimens which they may badly need for investigations. The primary purpose in compiling this list is to indicate possible sources from which such material may be obtained. Even though a collector may have but a few score skins, he is usually willing to make an effort to secure species needed by a fellow enthusiast. Another effect which it is hoped the appearance of this list will have is the stimulation of the interest of the small collector, the beginner and

the amateur. Few will undervalue the importance of gaining recruits for the study of mammalogy, for new blood is always needed in any line and can usually be secured, in natural history, only from the amateur field. A great incentive for increase of interest is in exchanging, which pastime has been largely instrumental, I am convinced, in building up the ranks of zoölogical enthusiasts. As the laws against the collecting of birds and eggs become more stringent, an increasing number will bend their natural history tendencies towards the study of mammals, and such should be given every possible encouragement.

Practically all museums are anxious to further research in every way, but their staffs are too busy for them to loan material to individuals except in special cases, nor are they, as a rule, able to undertake exchanges. Most private collectors are willing to exchange and to loan material to responsible parties. A few of the individuals herein listed have just begun gathering collections of mammals, but although these collections are now small, they will doubtless grow, and should be mentioned; others, with only a few skins on hand, habitually collect for institutions. In the case of private collections, the numbers given are usually only approximate, and do not take into consideration such skins as have been sent away in exchange. It has been deemed best not to include such institutions as have only a few mounted mammals, for these specimens are usually without adequate data, and are rarely of value to the investigator.

In the following pages, there are listed 37 public collections in North America containing 377,994 mammals; and 40 individuals with private collections aggregating 32,245 specimens—a grand total of 410,239 mammals.

PUBLIC COLLECTIONS IN THE UNITED STATES

American Museum of Natural History, New York City. This collection is very comprehensive for its size, and the mounted specimens are particularly fine and numerous. It contains the historic material of Maximilian of Wied, and of Verreaux. Particular mention should also be made of the splendid lot of African mammals acquired in recent years, and of the material obtained by the Andrews Asiatic expeditions. A tabular statement of the collection follows:

	NORTH AMERICA	SOUTH AMERICA	EUROPE	ASIA	AFRICA AND MADAGASCAR	AUSTRALIA	TOTAL
Primates	314	611	2	174	825		1962
Chiroptera	1582	1170	16	374	682		3824
Insectivora	440	37	50	354	319		1200
Carnivora	1853	491	43	331	804	3	3525
Glires	15613	4692	190	2761	1479		24735
Ungulata	963	190	57	353	1535		3098
Sirenia	2				1		3
Edentata	127	178					305
Effodientia				12	103		115
Marsupialia	311	476		2		104	893
Monotremata						16	16
Total	21205	7845	358	4361	5748	123	
Grand total							39640

Of these, 1284 are mounted, and 391 are type specimens.

Anatomical Laboratory, Western Reserve University, Cleveland, Ohio, has approximately 700 human skeletons, with 600 skulls and skeletons of mammals; especially rich in anthropoids, insectivores and marsupials.

Bureau of Biological Survey, Washington, District of Columbia. See United States National Museum.

Boston Society of Natural History, 234 Berkeley St., Boston, Massachusetts, has 650 mammals, mostly from the New England states, as it has not attempted to accumulate material from elsewhere.

Brooklyn Museum, Eastern Parkway, Brooklyn, New York, has about 350 study skins, mostly from the western states and the Orinoco region of South America. The most valuable material of this class in the museum consists of skeletons of various mammalian types.

California Academy of Sciences, San Francisco, California, has approximately 4000 mammals from western North America and the Galapagos Islands. Most of this material has been only slightly worked over and identified.

Museum of Vertebrate Zoology of the University of California, Berkeley, California, has 32477 specimens, including 1200 skulls without skins, 1300 skeletons, and 1200 alcoholics. The 90 types comprise 8 Carnivora, 8 Insectivora, 4 Chiroptera, 69 Glires and 1 Ungulata. The material is largely Californian, but valuable collections have been made in Alaska and British Columbia as well. The rodent genera *Dipodomys*, *Thomomys*, *Aplodontia*, and *Eutamias* are especially well represented, and the series of bears is the second largest in the country.

Carnegie Museum, Pittsburgh, Pennsylvania, has 5088 specimens, including skeletons, mounted mammals, and heads from the New World and Africa. There is no curator of mammalogy and the collection has not as yet been properly worked up.

MUSEUM OF COMPARATIVE ZOOLOGY, CAMBRIDGE, MASSACHUSETTS, has about 28000 mammals, with 250 types, in addition to some 16000 specimens of fossil mammals. The large collection of E. A. and O. Bangs was accessioned in 1901. The aims of the museum are universal in scope, and the mammals of the world are well represented, but, naturally, the material is chiefly North American.

COLORADO MUSEUM OF NATURAL HISTORY, DENVER, COLORADO, has 1600 mammals, almost all of them from that state.

COLORADO STATE AGRICULTURAL COLLEGE MUSEUM, FORT COLLINS, COLORADO, has 400 specimens, mostly from Colorado.

UNIVERSITY OF COLORADO MUSEUM, BOULDER, COLORADO, has about 400 skins, chiefly from the home state, but also from New Mexico and Arizona.

CONCORDIA TEACHERS' COLLEGE, RIVER FOREST, ILLINOIS, has some 100 skins from Ohio, Michigan and Arizona—this being a former collection of W. F. Henninger.

CORNELL UNIVERSITY MUSEUM, ITHACA, NEW YORK, has 700 specimens, about one half of which are alcoholics, from many states and countries.

DEPARTMENT OF BIOLOGY, FARGO COLLEGE, FARGO, NORTH DAKOTA, has about 100 skins.

FIELD MUSEUM OF NATURAL HISTORY, CHICAGO, ILLINOIS, has somewhat less than 25000 mammals, 182 of which are types. The collection is especially rich in west coast material, as well as in valuable collections from South America. The exhibition of mounted mammals is one of the finest in the country, especial attention having been given to large groups.

STATE UNIVERSITY MUSEUM, IOWA CITY, IOWA, has about 150 mammals and 250 odd skulls, mostly from Iowa.

MUSEUM OF NATURAL HISTORY, UNIVERSITY OF ILLINOIS, URBANA, ILLINOIS, has 100 specimens, mostly collected by the Crocker Land Expedition to northern Greenland.

ZOOLOGICAL LABORATORY, UNIVERSITY OF WISCONSIN, MADISON, WISCONSIN, has about 500 specimens, mostly from that state.

ZOOLOGY MUSEUM, KANSAS AGRICULTURAL COLLEGE, MANHATTAN, KANSAS, has 300 local mammals.

UNIVERSITY OF KANSAS MUSEUM, LAWRENCE, KANSAS, has 3000 skins, principally from the home state.

MUSEUM OF HISTORY, SCIENCE AND ART, LOS ANGELES, CALIFORNIA, has 600 skins from southern California and scattered points.

MUSEUM OF ZOOLOGY, UNIVERSITY OF MICHIGAN, ANN ARBOR, MICHIGAN, has about 2000 specimens from many localities in this country and abroad, and it is intended to build up a representative collection of the mammals of the world.

ZOOLOGICAL MUSEUM, UNIVERSITY OF MINNESOTA, MINNEAPOLIS, MINNESOTA, has 380 mammals, chiefly local, a few from Montana, and a lot of unclassified Philippine material, mainly osteological.

MONTANA STATE COLLEGE MUSEUM, BOZEMAN, MONTANA, has 400 specimens from that state only.

MONTANA UNIVERSITY, MISSOULA, MONTANA, has perhaps 1000 mammals from the home state.

UNIVERSITY OF OKLAHOMA, NORMAN, OKLAHOMA, has a mammal collection, but it is now being moved, and definite information can not be furnished.

Oregon Game Commission (S. G. Jewett, 515 Post Office Building), Portland, Oregon, has 1000 mammals from that state.

Department of Zoology, University of Oregon, Eugene, Oregon, has 1000 skins from Oregon, mostly the western section.

Academy of Natural Sciences of Philadelphia, Philadelphia, has about 8000 skins, 1000 mounted specimens, and 4000 alcoholics and skeletons of mammals, mostly from North America, but also many from foreign countries. This collection contains much material from the early expeditions of exploration, and is of great historical importance.

Natural History Museum, San Diego, California, has 1200 mammals, the great majority comprising the collection made by Frank Stephens, mainly from southern California.

Scripps Institution, La Jolla, California, has 1000 or more skins of *Peromyscus*, cleaned with benzine, and accumulated by F. B. Sumner in the course of his experiments in genetics. A large proportion were bred in captivity, and all have been measured and classified with painstaking accuracy.

Department of Zoology, Stanford University, Palo Alto, California, has 2500 specimens, mostly skins, but some skeletons and alcoholics, from the western states, Lower California and the Galapagos Islands.

United States National Museum, Washington, District of Columbia, includes the collection made by the Bureau of Biological Survey, and the two together reach the imposing total of 204,534 mammals—by far the largest lot under one roof in the world. A majority of the existing specimens collected by the early American naturalists are to be found in this institution. The collection of the National Museum (exclusive of the Biological Survey material) is shown in the following table:

	NORTH AMERICA	EUROPE	CENTRAL AND SOUTH AMERICA	ASIA	AFRICA AND MADAGASCAR	AUSTRALIAN REGION	TOTAL
Primates	37		219	1032	571		1859
Chiroptera	9901	652	781	3026	897	146	15403
Insectivora	2651	1245	7	1097	780		5780
Carnivora	5768	270	268	1095	625	6	8032
Glires	18637	3705	1374	9798	5955	183	39652
Ungulata	2443	61	239	1537	1876		6156
Edentata	86		171	22	12		291
Cetacea	787	9	7	25	8	4	840
Sirenia	24		11	40	1		76
Marsupialia	292		225	34		583	1134
Monotremata						46	46
Total	40626	5942	3302	17706	10725	968	
Grand total							79269

Of these, 1179 are type specimens.

The collection of the Biological Survey, United States Department of Agriculture, although a part of the National Museum collection included in the same series of catalogue numbers, is maintained as a separate unit under the charge of the Survey. It contains only mammals from North America (areas north of South America) and probably the main feature is the splendid series of Mexican mammals—the finest in the world. There are no mounted individuals nor alcoholics, these having been merged with the collection of the National Museum proper.

The suites of the larger carnivores from the United States obtained during recent years by federal trappers are especially fine. The following table shows the material included in the Biological Survey collection:

	ALASKA	CANADA	UNITED STATES	MEXICO	CENTRAL AMERICA	PORTO RICO AND CUBA	TOTAL
Primates				44	63		107
Chiroptera	5	30	1639	495	144	115	2428
Insectivora	1066	853	4456	454	72		6901
Carnivora	2417	3108	11657	1008	73	3	18266
Glires	3496	6599	70654	14077	742	2	94570
Ungulata	124	190	653	383	29		1379
Edentata			21	28	14		63
Marsupialia			201	114	236		551
Total	7108	10780	89281	16603	1373	120	
Grand total							125265

Of these, 724 are types.

STATE COLLEGE, PULLMAN, WASHINGTON, has about 400 mammals, chiefly from Washington, but a few from Idaho as well.

STATE MUSEUM, UNIVERSITY OF WASHINGTON, SEATTLE, WASHINGTON, has some 125 skins from that state and Alaska.

PUBLIC COLLECTIONS IN CANADA

PROVINCIAL MUSEUM, VICTORIA, BRITISH COLUMBIA, has 1500 small mammals from that province only.

VICTORIA MEMORIAL MUSEUM, DEPARTMENT OF MINES, OTTAWA, ONTARIO, has 3900 specimens, including mounted mammals and odd skulls, the largest number being from British Columbia, but other sections of Canada are well represented.

PRIVATE COLLECTIONS IN THE UNITED STATES

BERNARD BAILEY, ELK RIVER, MINNESOTA, has been collecting for 12 years, mostly for others, and has 100 Minnesota mammals.

C. F. Batchelder, 7 Kirkland St., Cambridge, Massachusetts, has 3000 specimens, chiefly from New England, but also a few from the Pacific Coast.

D. E. Brown, 87 Lenora St., Seattle, Washington, has collected for 3 years and has 530 skins from Washington and British Columbia.

M. L. Church, Charlotte, North Carolina, has collected intermittently for 18 years, and has 1000 skins from eastern North America.

D. R. Dickey, 514 Lester St., Pasadena, California, has been collecting since 1912 and has 5000 mammals, practically all from the home state. His is evidently the largest private collection of mammals in North America.

F. M. Dille, Valentine, Nebraska, has collected for 4 years, and has 150 specimens from Nebraska, Oregon and Wyoming.

J. M. Edson, Marietta Road, Bellingham, Washington, has been collecting for 2 years and has 100 local mammals.

I. N. Gabrielson, 575 Portland Avenue, Portland, Oregon, has collected for 3 years and has over 100 Oregon skins. He specializes on rodents.

A. H. Helme, Miller Place, Long Island, New York, has been collecting for 35 years and has something over 2000 skins.

D. V. Hembree, Roswell, Georgia, has 40 local mammals.

W. F. Henninger, New Bremen, Ohio, has been collecting for 15 years, but having disposed of former collection, now has only 150 specimens.

W. D. Hollister, Delavan, Wisconsin, collected during 5 or 6 years prior to 1911, and has 300 mammals from Colorado and New Mexico.

J. Hornung, 5219 South Wilton Place, Los Angeles, California, collected for 30 years, but had the misfortune to lose his collection in the San Franscisco fire, and now has 200 skins, 300 alcoholics and 2000 skulls. He is interested chiefly in anatomy.

A. B. Howell, 770 South Pasadena Ave., Pasadena, California, has been collecting mammals for 8 years, and has 3800 specimens, mostly from the western states and Alaska. He is interested especially in the Microtinæ.

R. W. Jackson, Cambridge, Maryland, has collected for a year and has 70 skins.

E. C. Jacot, Sunnyside, Arizona, has been collecting for 2 years and has 75 Arizona mammals.

S. G. Jewett, 515 Post Office Building, Portland, Oregon, has collected for 20 years and has 1000 Oregon mammals.

D. E. Kent, Rutland, Vermont, has been collecting 8 years and has 275 skins from western Vermont.

G. L. Kirk, Rutland, Vermont, has collected for 5 years and has 250 skins from that state.

J. E. Law, Altadena, Pasadena, California, has collected for 6 years and has 680 skins from southern California and Arizona.

L. Little, 1403 Garfield Avenue, South Pasadena, California, has been collecting 5 years and has about 200 mammals. He is interested chiefly in the Chiroptera.

K. B. Mathes, Batavia, New York, has collected for 3 years and has in the neighborhood of 150 skins, a number being mounted. He is interested in wood rats.

L. H. Miller, Southern Branch University of California, Los Angeles, California, has collected 4 years and has over 150 skins. His specialties are osteology and juveniles.

H. V. Ogden, 141 Wisconsin St., Milwaukee, Wisconsin, collected for 6 years prior to 1903 and has about 350 local specimens, half of them being skulls only.

A. S. Pope, 55 Pleasant Street, Waterville, Maine, has been collecting for 10 years and has 180 mammals. His specialties are *Sorex*, *Peromyscus* and the Chiroptera.

E. T. Seton, Greenwich, Connecticut, has collected for 40 years and has 1000 skins from Canada and New England. He is interested chiefly in the life histories of the smaller forms.

H. W. Shoemaker, McElhattan, Pennsylvania, has been collecting for 10 years and has 250 skins. He specializes on eastern mammals which are on the verge of extinction or have become extinct.

W. E. Snyder, Beaver Dam, Wisconsin, has collected for over 20 years and has 2500 specimens, mostly from Wisconsin. He is chiefly interested in weasels and squirrels.

D. D. Stone, Casa Grande, Arizona, has collected intermittently since 1874, and has 250 mammals.

M. H. Swenk, University Farm, Lincoln, Nebraska, has over 500 skins, chiefly from Nebraska, now housed with the State Entomological Collection.

H. N. Vars, Plainfield, Connecticut, has collected for 7 years and has 200 specimens from Connecticut and Florida. He specializes on squirrels.

A. Walker, Blaine, Oregon, has been collecting for 9 years, chiefly for others, and has 200 skins. He is interested principally in the smaller carnivores.

E. R. Warren, Colorado Springs, Colorado, has collected mammals for some 20 years and now has about 3500 specimens, the greater part being from his home state.

H. E. Wilder, Carlotta, California, has been collecting intermittently for 30 years. Most of his specimens have gone to various institutions and he now has but 75 skins.

L. E. Wyman, Museum of History, Science and Art, Los Angeles, California, has collected at different times for the past 7 years, has 200 mammals, and is interested chiefly in the genus *Glaucomys*.

PRIVATE COLLECTIONS IN CANADA

S. Criddle, Treesbank, Manitoba, has collected for 15 years and has 200 skins. His specialties are the Soricidæ and Rodentia.

J. H. Fleming, 267 Rusholme Road, Toronto, Ontario, has collected mammals a little for 30 years, and has about 220 of the smaller species, in addition to many horns, skulls of wood buffalo, panther skins, etc.

C. B. D. Garrett, Cranbrook, British Columbia, has been taking a few mammals for the past 19 years, and now has 200, mostly from British Columbia.

W. E. Saunders, London, Ontario, has collected for 30 years and has 600 mammals, mostly from eastern Canada.

J. D. Soper, Guelph, Ontario, has been collecting 7 years and has some 200 Canadian mammals.

Pasadena, California.

GENERAL NOTES

ON THE STATUS OF MUSTELA ALLEGHENIENSIS

When this species was first described by that most excellent naturalist S. N. Rhoads it was pointed out by him as well as by Mr. Todd of the Carnegie Museum that it was "allied to the minute Arctic and Canadian *Putorius rixosus* Bangs." The new species named was taken in Pennsylvania only. This was in 1901. In January, 1905, Prof. Albert A. Wright in the Ohio Naturalist wrote that it had also been taken in Jefferson County, Ohio, and added an eighth specimen to the seven already known, taken in Lorain County, Ohio, in January, 1904. He also said: "The justification for the publication of the species *allegheniensis* must lie wholly in the fact that there is so vast a gap of territory between the Saskatchewan and the Pittsburgh region crossed by one or two life zones, in which *P. rixosus* is not known to occur." And further "Unless some substantial difference is found the name *allegheniensis* will ultimately have to retreat and all the specimens be called *rixosus*." I understand that *rixosa* is said to have been taken in Wisconsin. In Ohio since 1905 weasels of this group have been frequently taken in Mahoning County, in Summit County, and in Franklin County. Lately one was taken in Darke County. In the winter of 1917 to 1918 one in winter pelage was taken north of Wapakoneta and is now mounted in the possession of Mr. Wm. Kayser, druggist in Wapakoneta. On Sunday December 11 a male in summer pelage was brought to me. It had been taken 3½ miles north of New Bremen. When an armful of corn fodder was thrown into the shredder this specimen jumped out and was caught in the belt, crushing its head. Otherwise it is perfect. It is now in my collection. Thus in 20 years it has been shown that *allegheniensis* occurs over most of the northern part of Ohio from its western boundary to Pittsburgh, Pennsylvania, on the east. That is, *rixosa* and *allegheniensis* have been brought closer together since 1901 by 250 miles. Real, earnest and persistent effort by Indiana mammalogists will no doubt prove it to occur there. If only more observers could be found to carry on the work, it would soon prove beyond a doubt, that Professor Wright's suggestion is correct and that *rixosa* and *allegheniensis* are the same, or if distinct then only subspecifically.—W. F. Henninger, *New Bremen, Ohio.*

EVIDENCE OF INTERRELATION BETWEEN FOX AND CARIBOU

It has always seemed to me that a contributor's column, designed for short notes, should look to the potential as well as to the established—to the suggestive as well as to the certain—and should welcome fragmentary suggestions and observations even though no final conclusions are possible at the time. The cumulative value of such notes is enormous. An experience of mine in Newfoundland, recalled by Sheldon's article in regard to the association of fox and big-horn (Journ. Mam., vol. 2, 1921, p. 234), falls into this category.

On November 6, 1916, I was watching the marshes of Sandy River, Newfoundland, for the caribou migration which was then an interesting subject for study. In those days the migratory herds had not been decimated by ruthless native slaughter of the females, as they were during the later years of the war. Toward ten o'clock of that day, the light—which is always a questionable factor in the

Island—brightened, so I hurried to my blind and quickly set up a motion picture camera. As I was doing so, I heard the roar of a large band of caribou (*Rangifer terræ-novæ* Bangs) plunging into the river on the migration leads above my blind. A moment later, the band, which consisted of thirty-four animals, came out into the open of the large marsh which I was covering. Because of the mild weather, the migration urge was momentarily weakened, and as a result the band immediately fell to feeding as soon as it had reached the open marsh.

A moment later I was astonished to see a light-colored red fox (*Vulpes deletrix* Bangs) walk out from a point of nearby timber, and zigzag casually through the middle of the band. The caribou seemed to be on perfectly good terms with the fox, and all in all his actions and their response reminded me exactly of a sheep dog working through a band of domestic animals. He wandered here and there among them, and finally drew apart and lay down on a little knoll while they fed. I was utterly at a loss to account for his having definitely sought out the band. It is possible that migrating caribou stir up meadow mice in their travels, and that foxes take advantage of this fact. I had no evidence, however, that this particular fox was in search of food when he joined the herd. It may well have been nothing more than a coincidence, or an expression of casual curiosity on the part of the fox, or a mere search for companionship with a non-competitive species. On the other hand, it may be that there is a definite interrelation between the travelling bands of caribou and the local foxes. If this is so, he may have trotted out to join the band with some definite and ulterior food-motive in his mind, such as that suggested above. But, as I say, this was not in any way proven, and the note is set down here in the hope of eliciting word of similar experiences from those who have had like chances for observation, rather than with the idea of formulating a definite conclusion. An interesting question is suggested. Its answer would show whether this was merely a casual or a normal instance of specific interrelation.

The caribou paid no attention to the fox beyond casting a casual glance in his direction when he passed within a few feet of their muzzles, as they fed. It seemed as though he definitely enjoyed their company, but that feeling may well have arisen in my own mind, as I watched him, without proper basis in fact. After half an hour's siesta in the midst of the herd, the fox jumped down from his knoll and trotted back into the timber from which he had come. As he did so, a few of the hinds gazed after him curiously, but most of the animals did not even raise their heads as he moved among them.—DONALD R. DICKEY, *Pasadena, California.*

FRIENDSHIP BETWEEN FOX AND CARIBOU

Many years of hunting in the forest have of course brought me many surprises. My opportunities to note and become interested in the habits of wild animals have been frequent, and in my experiences as a sportsman-naturalist I recall many incidents the like of which I have never seen in print. Among these there stands out one instance which impressed me at the time as most interesting and instructive. The fox is supposed to be a sort of freebooter and renegade of the woods, giving and accepting no friendships. This, however, is not so.

Many years ago, and before our caribou had vanished from Nova Scotia, an Indian companion and myself sat watching a herd of eleven caribou that were lying in the center of a large, moss bog in the interior of this province. My

rifle, a Snider, was good for about 200 yards for anything like a certain kill, and the animals sought were some 400 yards away. Looking them over with a powerful deer-stalking telescope I could note their every movement. All were lying down except one. This invariably was the habit of a herd; always one animal stood guard and we used to call it the "watchman." From over a barren hill came a fox. He stood and looked at the caribou, then trotted down towards them. The "watchman" saw him at once and turned slightly facing him; the resting herd all lay still. Right among the caribou walked the fox. He went from one to the other, flipping his brush from side to side, and rubbing his flank against their noses. They turned their heads slightly and seemed to enjoy the performance immensely. Perhaps I can better illustrate the instance by likening it to a domestic cat purring and rubbing against ones leg. That they were the best of friends there was no shadow of doubt.

For some time the fox played about among the animals and then, selecting a flat boulder, curled himself up right in the middle of the herd and went to sleep. It was a long way to camp and a storm was threatening, so, taking a chance, I held my snowshoes in front of me and began to crawl towards the game. The "watchman" stamped his foot and instantly every animal was upon its feet. The fox ran in and about among his friends apparently giving the alarm, and soon disappeared over the hill. Not so the caribou; their fatal curiosity, as always, got the better of them. They stood facing me and then began milling about. I was wearing a pair of scarlet lumberman's socks. Turning over on my back in the snow I kicked my feet in the air, and, glancing sideways, I saw the whole eleven trotting towards me. They finally walked up to within 50 yards of my position. Sitting up, I picked out the finest pair of the lot. Nine caribou raced away with a flurry of snow behind them, disappearing over the hill where their friend Reynard had preceded them.—H. A. P. Smith, *Digby, Nova Scotia*.

MUSEUM PRESERVATION OF INCISOR TEETH OF RUMINANTIA

Anyone who has had occasion to study the incisors of deer, sheep, antelopes, or other ruminant artiodactyls, knows the condition of these teeth in most museum specimens. He may search among dozens of skulls of a given species, in almost any large collection, and find hardly a perfect set. To begin with, the incisor teeth are extremely fragile and many are chipped or broken before the specimens reach the museum. After cleaning and thorough drying in a heated building they become as brittle as delicate china; the least quick blow will often break them and the very weight of the mandible becomes a menace to them when they are handled, since the teeth are almost certain at some time to strike some hard surface with disastrous results. In some collections the jaws are kept tied or wired to the skulls; then the added weight of the skull and horns makes certain the destruction of the protruding incisor teeth.

Now the incisor teeth of the ruminants are of particular value in systematic work, often possessing diagnostic generic or specific characters. They have not as yet been properly studied, and it would be quite impossible to find sufficiently large series of many species for thorough work. Doubtless the lack of perfect material is in a large measure responsible for the scant attention they have received. Certainly every museum might be expected to guard against the destruction of such important material, but it is nevertheless true that neglect is

the common condition. In some collections the jaws of large animals are merely piled on one another in large drawers, separate from the skulls, and virtually every set of incisor teeth has been ruined.

Since it is important to have large series, showing both milk and permanent incisors in all stages of wear, all museums should, in some manner and before it is too late, preserve from injury every perfect set of ruminant incisor teeth now in the collection or received in the future. At the National Museum, Mr. Gerrit S. Miller, Jr., has for a number of years been saving perfect sets of the incisors of artiodactyls in glass vials, such as are commonly used in most museums for keeping small mammal skulls. Possibly other museums have made some such efforts to preserve specimens, but I do not recall having seen evidence of it myself when looking over their material. Mr. Miller's method preserves the delicate teeth perfectly, and his efforts have built up a unique representative set of incisors of very great value. Except for his foresight the specimens would now be valueless for studies of these particular teeth. The method, though, while preserving the teeth themselves against injury, does not preserve them in proper position, and it is quite likely that in time the alveolar borders at the ends of the rami

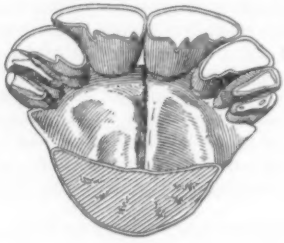


FIG. 1

from which the sets of incisors have been taken, will become broken, or the particular jaws temporarily lost, so that the exact natural position of the various teeth, in relation to one another, can not be determined for study or illustration.

A method which might obviate this difficulty would be to saw off the ends of the jaws, just posterior to or across the middle of the symphysis menti, number and label the specimens, and preserve all the incisor rows complete, in natural position, in trays lined with cotton, just as collections of eggs or other delicate objects are kept. A small case would hold hundreds of such sets of teeth and, thus assembled, they would be convenient for ready reference, study, and comparison. In no other way will it be possible permanently to preserve this valuable material from injury and still keep the teeth intact in proper place. It may be argued that this method ruins the mandible for study and measurement, but this argument surely has little weight against the desirability of perfect preservation of important specimens that will, under any other method, soon be ruined for all time. Saw blades are of comparatively uniform thickness, and at any rate only a millimeter or so of bone will be destroyed in the sawing, so that the longitudinal measurements of the mandible may still be taken with as much accuracy as is commonly attained.

If it is necessary to photograph one of the complete jaws for illustration the severed end of the mandible may be easily fastened in temporary position for the work by a bit of modeler's clay.—N. HOLLISTER, *Washington, D. C.*

NEOTOMA IN BERKS COUNTY, PENNSYLVANIA

Mr. Samuel N. Rhoads, in speaking of the Alleghany cave rat (*Neotoma pennsylvanica*) in his "Mammals of Pennsylvania and New Jersey" (p. 86), says: "Most diligent inquiry and field work in Pennsylvania east of Pine Creek and Williamsport in Lycoming and Tioga Counties, and in the entire country drained by the eastern and northern branches of the Susquehanna and all of the Delaware River drainage area, has failed to locate this rat's existence in recent times."

It may therefore be of interest to record that on September 2, 1921, I captured two adult specimens of this interesting rat on top of The Pinnacle, a spur of the Blue Mountains in northern Berks County, Pennsylvania. On a former visit to this locality I noted signs of these rats among the boulders and ledges near the top of the mountain, and resolved to attempt the capture of some specimens. Finally, on the date mentioned, Dr. J. J. Shelley of Stony Run and I spent the night on the mountain, after having previously set out several traps.

From the commotion which these animals made toward midnight I felt certain that there must be a very large colony about, and in the morning we were astonished to find that everything that we had left loose had been carried away by the rats, even down to our lunch and a pair of spectacles, which had been deposited on a flat rock within a couple of feet of where we slept. It also struck me as rather strange that the rats did not become active until well toward midnight, although they apparently continued their foraging until a very short time before sunrise.—EARL L. POOLE, *Reading, Pa.*

A BREEDING RECORD OF PHENACOMYS LONGICAUDUS

On May 22, 1921, Mr. Elmer Williams of Portland, Oregon, found a nest of *Phenacomys longicaudus* about forty feet up in a fir tree at Agness, Curry County, Oregon. Upon examination it was found to contain an adult female and three small, blind, and unhaired young. Unfortunately the specimens were not saved, neither were measurements taken. This adds something, however, to our knowledge of this interesting mouse.—STANLEY G. JEWETT, *Portland, Oregon.*

MICROTUS CHROTORRHINUS IN MAINE

While collecting small mammals on Mount Coburn in Somerset County, Maine, last summer I took in my traps three specimens of *Microtus chrotorrhinus* (Miller). As far as I can discover this is the first record for this species in the State of Maine. I believe that the only other recorded localities in the United States are the type locality, Mount Washington, New Hampshire, and the Catskills, New York. Mount Coburn is considered the third highest peak in Maine, being around 4500 feet. It lies in Somerset County, partly in township No. 2, range 6, and partly in Enchanted Township, being about twelve miles north of the Forks and about three or four miles south of Parlin Pond. It has a single high peak with numerous spurs and foothills, the whole being heavily wooded. One specimen was taken near the camp of the fire lookout at an elevation of approximately 3000 feet. At

this place there is a moderate growth of spruce and fir with occasional birches and much underbrush. The ground is rocky and at the spot where the mouse was trapped the rocks are heaped up so as to form large holes and spaces beneath them. They are covered with moss and the whole is very damp. A few feet away there is a spring and a small, trickling stream. The other two specimens were taken on the top of the mountain. The top is covered with a dense growth of scrub spruce and fir, so dense that it is difficult to make one's way through it. The ground is entirely composed of fragments of rock, averaging two or three feet in diameter, which are piled on one another leaving large spaces between and below them. The rocks are entirely covered with moss and the whole locality is very damp. The character of the ground agrees almost exactly with the description of the type locality and of other mountain localities.

The three specimens of *chrotorrhinus* were trapped on August 18, August 30, and September 1, respectively. All are males. The measurements are as follows: total length 169 mm., tail 47 mm., right hind foot 22 mm.; total length 137 mm., tail 47 mm., foot 21 mm.; total length 169 mm., tail 50 mm., foot 23 mm. I have compared them with topotypes from Mount Washington and with specimens from Quebec and found them to be similar to those specimens in all respects. The species did not appear to be very abundant on Mount Coburn. I had a line of about fifty traps set for twelve days at the lookout camp locality and for five days on the top of mountain but only caught the three specimens mentioned. One peculiar circumstance that I noticed was the fact that every morning I found about half of the traps which were set in the holes under the rocks on the top of the mountain sprung with nothing in them. Such a thing rarely happens in other localities. One of the two specimens caught at the summit was not in the trap but had been hit on the nose and killed when the trap snapped. Whether or not this means that *Microtus chrotorrhinus* is too quick or too clever for the trap I would hesitate to say.

The present known extent of the range and this newly recorded locality makes it seem likely that *Microtus chrotorrhinus* exists on other mountains in Maine. Mount Katahdin would seem to be an ideal locality for the rock vole. The big Maine woods are by no means exhausted as a field for the mammalogist.—LELAND C. WYMAN, *Boston University School of Medicine.*

NOTES ON THE YOUNG OF THE SOUTHERN POCKET GOPHER

The San Diego Museum of Natural History has recently acquired a brood of young southern pocket gophers (*Thomomys bottæ pallescens*) presenting unusual interest. As the early life history of these rodents is shrouded in more or less mystery I consider these notes worthy of record.

The brood of four was taken from a nest in an orange grove about twelve miles west of San Diego, March 1, and was presented by Mr. J. W. Sefton, Jr. The age is somewhat in doubt, as might be expected, but they were yet "blind" though of about the size of our largest *Peromyscus* (three and a half inches from the nose to base of tail). Below from the median line the skin is entirely bare. Dorsal surface and sides with short coat corresponding to color of adult.

The most striking features are the lack of an open pouch, which is indicated by only a wrinkle at the side of the mouth, where in the adult would be found the well known "pocket," and within the mouth by a loose flap of skin; and in the

manner in which the large upper incisors do not appear to pierce the skin as in the adult. In the young before me the lips have begun to send, from each side, small extensions of furred skin, that in a short time would have met and joined, forming the "isthmus" of fur behind the incisors, but at this age are about $\frac{1}{16}$ of an inch apart at the nearest point.

The nest was at the end of a short side issue from the main burrow, about 10 inches from the surface of the ground, and at the root of an orange tree. A large handful of finely shredded vegetable fiber composed the bed on which the youngsters were nestling.—A. W. ANTHONY, *Nat. Hist. Mus., San Diego, Calif.*

THE RARE NAPÆOZAPUS INSIGNIS

In late August and early September, 1920, I went on a canoe trip of some two-hundred miles through the Temagami Forest Reserve of northern Ontario, and down the Montreal River to Lake Timiskaming. I carried a light outfit for collecting and preserving small mammals. Of anything I had in mind, I looked forward most eagerly to the woodland jumping mouse, for the country was obviously favorable to its presence from geographic and other standpoints. As I had failed to find this animal on several other trips to localities of boreal aspect, I went to Temagami with tempered expectancy.

However, on the fourth morning out on Ababika Lake, I caught my first *Napæozapus* in a trap set the previous evening among drift on the margin of a sandy cove. The place was overhung by spruce, cedar, birch, balsam, and alder. The forest here was very old, heavy, and moss-carpeted.

My second and last specimen was taken two days later (September 4) on Wakimika Lake some distance to the northwest. Both localities are within the forest reserve. With *Napæozapus*, the same night in the same situation, I trapped three specimens of the Hudson's Bay jumping mouse (*Zapus hudsonius*). The two species are readily distinguished. In this case the traps were set upon the sand of the beach under low shrubbery. The general situation reminded me of Point Pelee, Lake Erie. I was attracted to this comparatively open situation among the scattered shrubbery by the presence of numerous mouse trails in the fine sand. Some of these were made by the white-footed mouse (*Peromyscus*), just as at Point Pelee they are made by his relative *P. m. bairdi*. The adjoining forest was the typical boreal forest of the Canadian Zone—spruce, balsam, red pine, etc., spruce predominating.

Following are the measurements of *Napæozapus insignis*. No. 437—♂—length, 227 mm.; tail vertebræ, 150; hind foot, 32. No. 439—♂—length, 230 mm.; tail vertebræ 147; hind foot, 31.—J. DEWEY SOPER, *Edmonton, Alberta.*

THE RED SQUIRREL EXTENDING ITS RANGE IN INDIANA

Prior to August, 1909, the writer had collected and studied birds and mammals about his boyhood home near Sheridan, in central Indiana. At this time fox squirrels were common in the woods and the avenue surrounding the home, but red squirrels were not known to occur closer than eight miles northeast, three or four miles northeast of Sheridan. In fact, the writer recalls having made a trip about 1907 or 1908 to this, the nearest, colony of red squirrels, to get specimens which he could not obtain near home.

When visiting his home in March, 1921, the writer learned that the red squirrels have now reached the immediate vicinity. His father stated that the reds are increasing and apparently driving out the fox squirrels. The home is surrounded by an open avenue of oaks, walnuts, and other forest trees, which gives an excellent opportunity to observe the animals as they come even onto the steps of the house.—ERNEST P. WALKER, *Biological Survey, U. S. Department of Agriculture.*

YOUNG GRAY SQUIRRELS AT HUDSON, WISCONSIN

On the morning of Saturday, September 3, 1921, I was walking outdoors when I saw a squirrel coming down one of our trees with what appeared to be a rat in its mouth. I told my companion, a little neighbor girl named Grace, to chase the squirrel and see if the object it carried was a rat. She came back shortly, saying that she had chased it to the other end of the block, where it had climbed a large elm tree and jumped to the roof of a school house with its burden and she had been unable to get near enough to be sure what it carried.

About fifteen minutes later I saw the squirrel coming down the same tree with a similar object in its mouth. Again I told Grace to chase the squirrel and get what it carried as I was anxious to know if squirrels ate rats. Again she pursued the squirrel with its burden, and this time came back announcing triumphantly, "I grabbed it out of its mouth and it's alive," as she dangled a wiggling object by the end of its tail. To my utter dismay I beheld it was a baby squirrel with eyes not yet open, and I would guess not more than two or three days old.

When I thought how I had caused that poor mother carrying her baby to be chased, I felt like a criminal though my act was caused by ignorance of the fact that a squirrel raised a family in the fall. I told Grace to go back where she had gotten the baby, and if she could see the mother, to lay the baby down; but Grace was unable to see the mother and so brought the baby back again. We then placed the baby on a soft cloth in a basket, which latter we set at the foot of the tree down which the squirrel had come.

Shortly after we saw the squirrel start down the tree with a third baby in her mouth, but seeing us she evidently decided against that course, and went back up the tree. Grace and I then went off to the lake, and were gone two hours. On our return we found the baby still in the basket. We fed it warm milk from a medicine dropper, and it took the milk greedily. We repeated the feeding every two hours, and the baby took about one and a half dropperfuls each time. But night came and to our disappointment we had seen no more of the mother squirrel, though we had discovered the nest in the tree from which she was removing her babies; and I remembered having thrown water from a hose up there, unintentionally, a day or two before, which probably accounted for her decision to take her babies elsewhere.

At nightfall we carried the basket with the sleeping baby squirrel into the house for fear of cats. The next morning about six o'clock I saw the mother in the yard. Upon seeing me she ran up a tree. I quickly got the basket with the baby squirrel, which I had just fed, and placed it in a crotch of the tree in which the mother was, and I went into the house. She at once came down to the basket, sniffed at the baby a few times, as though to be sure it was her own, picked it up with her front paws, patted it, smoothed it, and taking it in her mouth carried it to the roof of the old school house where she had taken the rest of her babies.—ESSIE W. WILLIAMS, *Hudson, Wisconsin.*

MEAT-EATING PROPENSITIES OF SOME RODENTS OF MINNESOTA

Sciurus carolinensis hypophœus. Gray squirrel.—The sheet in my looseleaf catalogue containing notes on the food of the gray squirrel has been torn out and lost but I find a card containing the following which may be of some interest: List of birds' nests seen being robbed by gray squirrels in 1914—Baltimore oriole, chipping sparrow, robin, and blue bird. In my pocket notebook for 1915 I found this note: June 10, I saw a gray squirrel enter a hollow limb, 25 feet from the ground and come out with a half grown bluebird in its mouth. The bird was still alive.

Sciuropterus volans.—Southern flying squirrel. Near Elk River, Minnesota, July 4, 1920, I drove one out of a martin house and shot it. The stomach contained meat and pin feathers. I had taken a young martin from the same house earlier in the day which had been recently killed and partly eaten. Another young martin had been taken from the same house a week before in the same condition. No young martins were left in the house when it was taken down at 2 P.M. The squirrel was an adult female.

Citellus tridecemlineatus. Striped ground squirrel.—Near Elk River, Minnesota, June 10, 1921, I heard a small brown Leghorn chicken which seemed to be in pain; on going to investigate, I found it struggling to get away from something in a bunch of weeds. Just as I found it, it escaped but only got two feet before I saw it caught again and by a "striped gopher." I ran to the spot at once but the chicken had been bitten under the wing, and was dead within half a minute after I arrived. The ground squirrel left the chicken as soon as it saw me. It was killed and proved to be an adult female in milk. The chicken was hatched May 23, 1921.—Bernard Bailey, *Elk River, Minn.*

RECENT LITERATURE

Vorhies, Charles T., and Walter P. Taylor. LIFE HISTORY OF THE KANGAROO RAT, DIPODOMYS SPECTABILIS SPECTABILIS MERRIAM. Washington: U. S. Department of Agriculture Bulletin No. 1091 (also Technical Bulletin No. 1 of Agricultural Experiment Station, University of Arizona); pp. 1–40; 9 half-tone plates and 3 text figures. September 13, 1922.

This paper is the result of an intensive study of the life history of the banner-tailed kangaroo rat (*Dipodomys spectabilis spectabilis* Merriam), and on this score it is a valuable contribution. Attention is also given to the relation of this rodent to grazing as affecting the 50 square miles of territory known as the United States Range Reserve in Pima County, Arizona. The outstanding feature in the basis of this study is the large number of burrows or dens that were excavated and examined. Twenty-four food stores are reported upon in detail. The amounts and kinds of food stored are shown in a graphic and illuminating manner by a series of well-planned photographs. A table is given correlating the quantity of storage per den with the time of year and with conditions governing plant growth during the preceding seasons.

It is to be regretted that similarly detailed facts were not available for the chapter on breeding habits and natural checks. Allowance should be made for the fluctuations in rate of reproduction as between good and lean years, just as was done in the case of food stored. The natural enemies of the kangaroo rat were not definitely determined, nor the degree of natural check upon the species from other causes. This portion of the paper is weak, confessedly.

Vorhies and Taylor estimate, from actual count, that there are on the average two kangaroo rats per acre over the territory studied. At this rate there would be 64,000 kangaroo rats on the 50 square miles of the Range Reserve. The amount stored by each rat is figured at 4 pounds. Much of this material, 85 per cent in ascertained cases, consisted of seeds and crowns of grasses, chiefly grama grasses of various species, which are important forage plants. It is estimated that the food stored annually by the kangaroo rats on the 50 square miles of the reserve would feed 14 steers for that year. To the ordinary cattleman the loss of 14 head on 32,000 acres would not be ruinous; yet we are assured that in Arizona such a loss "might mean the difference between success and failure!" The investigators recommend that the kangaroo rat should be let alone, unless its presence threatens valuable agricultural or grazing lands, in which case control measures, as set forth, should be applied. —*Joseph Dixon.*

Cabrera, Ángel. MANUAL DE MASTOZOOLOGÍA. Manuales-Gallach, No. 120; 440 pp., 6 colored plates and 176 figures in the text. Calpe; Madrid and Barcelona, 1922.

This modern work on mammals and how to study them should greatly stimulate interest in the group in all Spanish-speaking countries. There is nothing quite like it in any language, and readers of Spanish are to be congratulated on the appearance of such an attractive, handy, and authoritative work for their use. As indicated by his title, the author objects to the use of the word "mammalogia" on the old ground that it is a hybrid, and expresses his preference for a term derived wholly from the Greek.

The twelve chapters cover a wide range of subjects including the structure and life of mammals, palæontology, geographic distribution, classification, an outline of the recent and fossil groups down to genera, the uses of mammals, domesticated species, hunting and trapping, the preparation of specimens and methods to be employed in their study. Each subject is accompanied by a well-selected list of titles for further reference and the whole work is presented in a popular but strictly scientific manner. The author is fortunate in that he is his own illustrator, and the numerous text-figures well show the advantage; at every point and in the most artistic manner they bring out exactly what he wishes to express to supplement his text. The colored plates of the jaguar and the howler monkey are especially good, and place Cabrera among the foremost of mammal artists.

The book deserves special recommendation for students of natural history in the Spanish-American countries, where such an up-to-date manual has long been needed and where it will certainly do much good. —*N. Hollister.*

Thomson, J. Arthur. OUTLINES OF ZOOLOGY. Seventh Edition, revised. New York: Oxford University Press, American Branch, pp. i-xxii, 1-869, figs. 1-421. $6. 1921.

This is the seventh edition of a standard book too familiar to zoologists to require detailed review. As stated in the preface, it is "intended to serve as a manual which students of zoology may use in the lecture room, museum, and laboratory, and as an accompaniment to several well-known works, cited in the Appendix, most of which follow other modes of treatment." The book should serve as a handy lecture-room and laboratory reference, and might well be adapted to use as a text-book in such colleges as still adhere to the pedagogically sound method of teaching beginning zoology by morphology and representative types instead of by the fanciful method of introducing the students into a framework of philosophical zoology upon no foundation. The book should also prove useful as a reference to *general* zoology for taxonomists and others who work along specialized lines.

The part of the work dealing with the Mammalia covers 103 pages, a fair proportion of the book. We find herein several minor points for criticism, as, for example, the group Lagomorpha is treated as a sub-order of the order Rodentia, whereas most mammalogists nowadays consider Lagomorpha an order by itself. More noticeable, however, the seals in one place are included in the Carnivora (p. 14), and in another, classified with the Pinnipedia (p. 778), the mammals of which order, however, are designated as "Marine Carnivores." Such inconsistency and lack of definition are hardly excusable. These criticisms should not be taken too seriously, for the book as a whole is a valuable text on general zoology. —*Hartley H. T. Jackson.*

ALLEN, J. A. Sciuridæ, Anomaluridæ, and Idiuridæ collected by the American Museum Congo expedition. Bull. Amer. Mus. Nat. Hist., vol. 47, pp. 39-71; colored plate. October 27, 1922. (New forms of *Heliosciurus*, *Funisciurus*, *Anomalurops*, and *Idiurus*.)

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CORRESPONDENCE

HIBERNATING HABITS OF CHIPMUNKS

Editor of the Journal of Mammalogy:

A search of the literature of the American chipmunks reveals surprisingly little information concerning their hibernating habits. It is of course well known that both the eastern and western chipmunks (*Tamias* and *Eutamias*) store food extensively in summer and autumn and that they retire to their burrows during the coldest period of the winter, but the question as to whether they regularly become dormant, as do the woodchucks, ground squirrels, and prairie dogs, is not satisfactorily answered.

Several naturalists have excavated the burrows of the eastern chipmunk (*Tamias striatus*) in November and found the occupants active[1] and Bachman opened a den in January and found the chipmunks awake, but sluggish.[2] C. C. Abbott records an instance—the only one I have come across—of finding (in March) a chipmunk actually dormant in its burrow.[3]

There is even less known about the winter habits of *Eutamias*, and apparently there is no published record of the examination of the winter den of any of the species. Enos Mills devotes a chapter in his "The Rocky Mountain Wonderland" to the chipmunks and in it mentions having found chipmunks "in a heavy sleep in their beds," but unfortunately he does not give any further details and there is a strong probability that the animals referred to were ground squirrels of the genus *Callospermophilus* and not true chipmunks.

Here, it seems to me, is a most promising field for some of our mammal students who are located where they can watch chipmunks in the fall, locate their used burrows, and later dig them out and give us some definite facts about this most interesting habit. This letter is written in the hope that some of the readers of the Journal will undertake such studies and send the results in for publication.

Arthur H. Howell.

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[1] Kennicott, Robt., Quadr. Illinois, in Rept. Commr. Patents for 1856 (1857), p. 72; Abbott, C. C., A Naturalist's Rambles about Home, pp. 62–63, 1884.

[2] Audubon and Bachman, Quadr. North Amer., vol. 1, p. 70, 1846.

[3] Op. cit., p. 59.